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# MADROÑO

A WEST AMERICAN JOURNAL OF BOTANY

VOLUME XVIII

1965-1966

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To you, ANNETTA MARY CARTER—"Señorita Anita" south of the Border—recent President of the California Botanical Society, long-time Secretary of the Editorial Board of *Madroño*, and during three administrations the leavening spirit of the University of California Herbarium, we affectionately dedicate this volume.

During your long association with the University Herbarium, from student assistant to Principal Museum Scientist, you have been the trusted advisor of faculty and administrative officers, a generous counselor and confidante of successive generations of grateful students, and an esteemed friend to your associates and herbarium visitors.

Champion of human rights and friend of the friendless; interpid field botanist and indefatigable collector and interpreter of the plants of the remote ranges of Baja California, especially of the Sierra de la Giganta; gracious ambassadress to our Mexican botanical friends—you have shown in all your broad and varied responsibilities over the years an unfailing skill and competence which is overshadowed only by your personal warmth and outstanding human spirit.



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## ERRATA

- Page 26, delete 3rd line from the bottom and replace by  
*Cottea pappophoroides* Kunth. Mexico. Sonora, *Palmer 339*, in 1887 (YU).
- Page 93, delete first US and replace by UC
- Page 124, line 26, *E.* should be *Eriogonum*
- Page 124, under *Eriogonum* correct J. L. Reveal & J. L. Reveal to J. L. Reveal & J. A. Reveal
- Page 124, under *Eriogonum* correct A. H. Holmgren to N. H. Holmgren
- Page 135, line 13, correct spelling is *encelioides*
- Page 135, line 14, correct spelling is *PENINSULARIS*
- Page 149, note 2, line 2, correct spelling is *carinatum*

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# THE INTER-RELATIONSHIPS OF THE ALASKAN LUPINES

DAVID B. DUNN

This paper is an attempt to clarify the complex relationships of *Lupinus arcticus*, *L. nootkatensis*, and *L. polyphyllus*. These are three of the northernmost species of a genus which has fascinated both professional and amateur botanists as well as horticulturalists and agronomists. Specimens upon which this study is based are deposited in the following herbaria: CAS, DAO, DS, GH, ISC, MO, PH, RENO, RM, UBC, UC, UMO, V, and WIS.

Recently Phillips (1955) reduced *L. arcticus* to a subspecies of *L. polyphyllus* and *L. nootkatensis* to a subspecies of *L. perennis*. I find both of these transfers of rank untenable. Since Phillips cited no material other than type specimens and annotated a limited number of specimens, it is difficult to understand on what he based these changes.

I believe that Anderson's methods (1949) offer the most sound means of interpreting species which have abundant morphological diversity but still permit occasional hybrids to form. In fact, if the presence of fertile hybrids is the criterion used in reducing the taxa referred to above to subspecific status, it would be necessary to reduce an entire series of very different morphological entities of the northwestern United States, as shown by the following list of putative hybrids (morphological intermediates). I have been hybridizing both annual and perennial lupines for the past 20 years and the hybrids have been almost invariably morphologically intermediate between the parents. It is also possible to demonstrate beyond reasonable doubt that these specimens are of hybrid origin by the use of pictorialized scatter diagrams. Six of the putative hybrids listed below have been plotted in Figs. 1-3.

It would be necessary to make additional diagrams for the species not treated in the present paper to demonstrate that the specimens listed actually do fall into place between the two parents. Some of the putative hybrids have been collected within the last 20 years, while others were collected much earlier. Hence, only part of the specimens in the list may be attributed to man's activities in the transport of seeds and the development of habitats suitable to hybridization.

TABLE 1. LIST OF PUTATIVE HYBRIDS OR INTERMEDIATES IN HERBARIA

*L. polyphyllus* (fig. 4) one parent  $\times$ :

*L. arbustus* ssp. *pseudoparviflorus*. Vegetatively mostly *pseudoparviflorus* but the flower structure can be accounted for by a blend of the characters of both. Montana. Lolo Valley, Kirkwood 1199 (MO); Hamilton, Blankinship 772 (MO).

*L. arcticus* (fig. 4). Alaska. 60 mi S of Fairbanks, Barkalow P21 (ISC, figs. 1, 3); Richardson Highway, mi 350, Anderson 2764 (ISC, figs. 1, 3). British Columbia. near Barkerville, Calder & Savile 14224 (DAO).

*L. nootkatensis* (fig. 4). Alaska. Hope, *Anderson* 6589 (ISC, figs. 2, 3); 6589b (ISC); Kenai Peninsula, *Calder* 6207 (DAO); 6907 (DAO); 5728 (DAO). British Columbia. Queen Charlotte I., *Calder, Savile, & Taylor* 21382 (DAO, UMO, figs. 2, 3); Skeena Station, *Calder, Savile, & Ferguson* 13287 (DAO, UMO, figs. 2, 3); Prince Rupert, *Taylor & Lewis* 710 (DAO). Prince Edward I., *Fernald & St. John* 11104 (GH).

*L. perennis*. In areas where both are probably introduced. Nova Scotia. Colchester Co., *Zinck* 371 (DAO). Victoria Co., *Bassett* 1778 (DAO). Prince Edward I., *Bassett* 1622 (DAO); probably backcrossed to *L. perennis*; *Groh*, 1926 (DAO, primarily *L. perennis*, a few characters show introgression).

*L. arboreus*. Probably a garden hybrid or field hybrid in an area where *L. arboreus* was introduced. British Columbia. Vancouver I., *Newcombe*, 1931 (V).

Unknown or uncertain second parent: a. Some parent in the *L. lepidus-sellulus-lyallii* group. Oregon. Klamath, *Peck* 9551 (MO). b. Possibly *L. arbustus* ssp. *neolaxiflorus* Dunn. Washington. Seattle, *Freiberg*, 1915 (MO). c. Unknown or transitional material to *L. prunophilus*, which has been treated as a variety of *L. wyethii*, *L. polyphyllus* and *L. arcticus* and as a species. The spreading sparse, pilose to hirsute hairs on the stems, petioles and midvein of the lower side of the leaflets, as well as cilia along the acumen of the keel are characters found in *prunophilus*; plus the habitat, on dry mountain slopes in open forests, eastern Oregon and Wash. Oregon. *Cusick* 1926 (MO). d. Unknown sources or mutant. Very narrow linear leaflets, a narrow banner and the acumen slants forward instead of the usual falcate condition. Washington. Chehalis Co., A. & G. *Heller* 3878 (MO); Snohomish Co., *Thompson* 6805 (GH, MO); Thurston Co., *Meyer* 943 (MO). e. *L. albicaulis* (?). This is the material that Heller named *L. pallidipes* and Smith reduced to a variety of *L. polyphyllus*. It is characterized by rusty strigose hairs above and below on the leaflets, in age; also ecologically distinct, growing in a dry rocky site, and flower structure intermediate. (Washington. Chelan Co., *Thompson* 6429 (MO, upper leaflet surface glabrous). Oregon. Benton Co., *Searing*, May 22, 1925 (MO); Klamath Co., *Rose* 1241b (MO); Lane Co., *Heller* 10041 (RENO, type of *L. pallidipes*).

*L. nootkatensis* one parent  $\times$ :

*L. arcticus* ssp. *arcticus*. Alaska. King Salmon, *Schofield* 2033 (DAO, fig. 3).

*L. arcticus* ssp. *subalpinus*. British Columbia. Bennett, *Mitchell* 155 (DAO)

*L. (kuschei* ?). Alaska. Adak I., *Dowart* 32 (ISC); without locality, *Glassberg* 980 (ISC). Both of these specimens would be explainable if they came from the upper end of Lynn Canal toward Skagway since *L. kuschei* was described from Carcross and Whitehorse, Yukon.

*L. polyphyllus*. See above.

*L. arcticus* one parent  $\times$ :

*L. kuschei*. British Columbia. Mt. Apex, *Calder & Savile* 10759 (DAO). Yukon. Near Whitehorse, *Gillett & Mitchel* 3040 (DAO); 3431 (DAO); *Gillett & Ca'der* 3179 (DAO); *Kusche* (CAS 62470), head of Dease L., *McCabe* 8819 (UC).

*Lupinus polyphyllus* has a natural range extending from central California into British Columbia in sites of a rather wet habitat (fig. 5). The material in Alaska appears to have been introduced since it does not show a natural continuous distribution and since the material from the Kenai Peninsula had very few specimens which could be considered as true *L. polyphyllus*. Most of the population suggested a hybrid swarm such as the *Iris* colonies reviewed in *Anderson* (1949). The Kenai Peninsula area near Hope and Anchorage has had considerable disturbance by man. In addition, the coastal stretch of British Columbia would appear either to be so poorly collected that none were found or else it has a long stretch



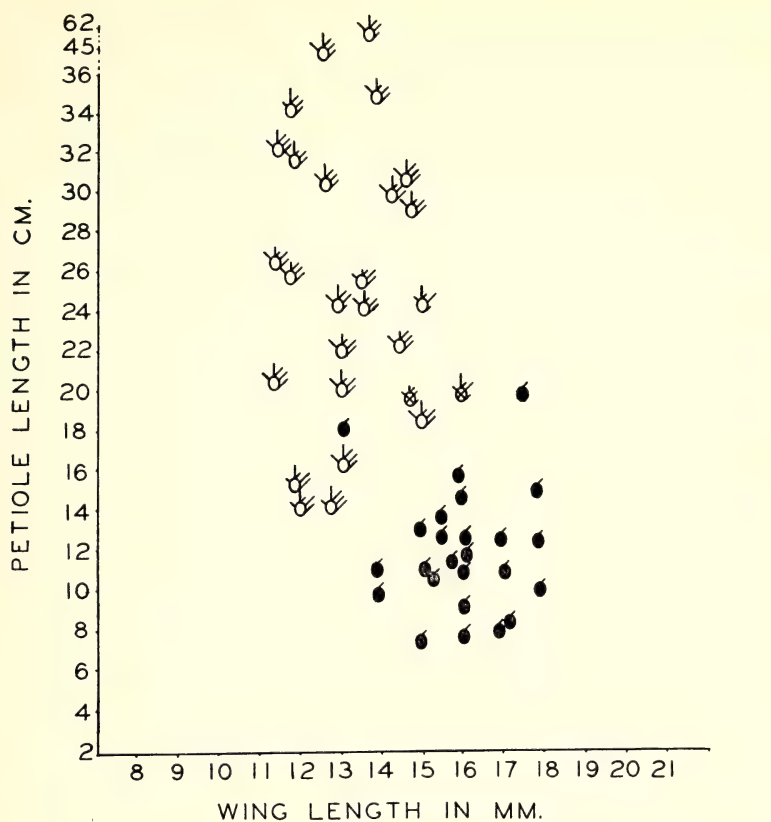


FIG. 1. Scatter diagram comparing of *L. polyphyllus*, open glyphs, and *L. arcticus*, solid glyphs. Putative hybrids are indicated with a cross in the glyph. Petiole length is that of the lowest fully developed leaf (also in figs. 2, 3).

devoid of *L. polyphyllus*. In the southern part of the range of *L. polyphyllus* two of the populations have become moderately distinct and have been treated as subspecies by Munz (1959). Of these two *L. polyphyllus* ssp. *superbus* is apparently a relatively stabilized taxon derived by introgression from *L. latifolius*. The blend of characters has permitted the occupation of wet meadow habitats within a geographic area otherwise primarily suited to *L. latifolius*. These southern taxa will be

treated in a latter paper. In western Oregon *L. polyphyllus* var. *pallidipes* appears to be of hybrid origin, combining traits from *L. polyphyllus* and apparently *L. albicaulis*. In eastern Oregon, Washington, and Utah *L. prunophilus* appears to have had some of its genetic traits derived from *L. polyphyllus* but the other sources are still obscure. In northern Washington, southern British Columbia, and western Montana, *L. polyphyllus* forms hybrids with *L. arbustus* ssp. *pseudoparviflorus* as cited above, which by backcrossing appear to be the source of the material referred to as *L. laxispicatus* var. *withamii*, as well as, introducing a glabrous keel in a portion of the population (Dunn, 1956), where these latter two names were treated as synonyms. Specimens within the range of *L. arbustus* ssp. *neolaxiflorus* were obvious hybrids between that taxon and *L. polyphyllus*. In British Columbia a finely, sparsely sericeous condition of the upper surface of the leaflets and ciliation on the keel were mute evidence of introgression from yet another undetermined source. Hybrids of *L. polyphyllus* with *L. nootkatensis* were observed from British Columbia, Alaska, and Nova Scotia (fig. 2). The introduced populations of *L. polyphyllus* on Prince Edward I. and in Nova Scotia now contain hybrids with the eastern *L. perennis*. Only a few hybrids with *L. arcticus* ssp. *arcticus* were found, but the flower structure suggests that both *L. arcticus* and *L. polyphyllus* contributed to *L. nootkatensis*. The latter has many distinct characters of its own as well as others derived from other sources. In short everywhere that *L. polyphyllus* has come into contact with another lupine, there has been some hybridization and subsequent introgression. In spite of this, it continues to maintain its distinctness. Several putative hybrids in which *L. polyphyllus* characters dominate have been included in the list, even though the second source of genes cannot be determined.

KEY TO TAXA TREATED AND OTHERS HYBRIDIZING WITH THEM OR IN CONTACT  
GEOGRAPHICALLY

- Banner reflexed above midpoint, sulcus deep, clasping the wings; calyx spurred or gibbous at base; wings pubescent or glabrous; leaflets glabrous or pubescent above ..... *L. arbustus* (Dunn, 1956)
- Banner reflexed approximately at midpoint, tip well separated from tips of the wings; calyx gibbous or not, not spurred; wings glabrous.
- Longest petioles basal or on radical shoots.
- Leaflets glabrous above, occasionally with a few marginal hairs.
- Bracts subsistent; flowers small, 10 mm long or less; pedicels 1-3 mm long; Wyoming, Montana, and Idaho..... *L. burkei* (not treated)
- Bracts caducous; flowers 10-20 mm long; pedicels 4-17 mm long.
- Stems with numerous hirsute, spreading hairs, 3-4 mm long; keel ciliate toward the acumen; Washington, Oregon, Idaho, Utah, and Nevada.  
*L. prunophilus* (Dunn, 1956a, and treated)
- Stems with appressed pubescence and some spreading pilose hairs, generally less than 2 mm long (except occasionally in *L. polyphyllus* ssp. *poly-*

*phyllus*, which introgresses with the last); keel glabrous (sometimes ciliate in *L. arcticus*).

Stems generally slender, 3–4 mm in diameter, with 2–4 cauline leaves; plants usually 2–3 dm tall; racemes of 2–8 well spaced verticils.

3a. *L. arcticus* ssp. *arcticus*

Stems fistulose, 4–8 mm or more in diameter; plants generally 6–9 or 15 dm tall; racemes elongate, 20 cm or more long at maturity.

Leaflets generally 10–17, elliptic-ob lanceolate, acute to acuminate; keel glabrous (except for hybrids or hybrid colonies); stream-sides and wet meadows, primarily in areas of high rainfall of British Columbia, Washington, Oregon, and California

1. *L. polyphyllus* ssp. *polyphyllus* var. *polyphyllus*

Leaflets generally 6–9, oblanceolate, rounded or acute; keel with minute papillae above the claws; endemic in the Sierra Nevada of California and Nevada.....*L. polyphyllus* ssp. *suberbus* (Munz, 1959)

Leaflets pubescent above.

Plants 4–10 dm tall; stems fistulose; keel slender, falcate, angle less than a 90° angle.....*L. polyphyllus* ssp. *polyphyllus* var. *pallidipes* (Munz, 1959)

Plants 2–5 dm tall; keel angle about 90°–120°.

Flowers slender, viewed laterally; banner elliptic to obovate; bracts persistent.....*L. lepidus* complex (not treated)

Flowers orbicular, viewed laterally; banner orbicular to broadly obovate; bracts persistent in *L. kuschei*, tardy or caducous in *L. cottonii*, *L. ornatus*, *L. humicola*, *L. wyethii*.....(none treated)

Longest petioles cauline, several leaves above base.

All petioles short, about as long as leaflets to slightly longer; leaflets linear to linear-ob lanceolate.....*L. rivularis*, *L. arboreus* (not treated)

Longer petioles 1½–4 times as long as the leaflets.

Foliage finely sericeous; keel glabrous, strongly arcuate-falcate, angle about 80°; stems solid; banner tip acute.....*L. albicaulis* (not treated)

Foliage finely strigose to sericeous or glabrate; leaflets generally glabrous above (note a % in *L. nootkatensis* and in *L. arcticus* ssp. *subalpinus*); keel usually ciliate; stems hollow, often fistulose.

Plants rhizomatous with slender stems arising singly or several close together; keel ciliate toward the acumen; eastern North America, west to Minnesota and Iowa.....*L. perennis* and allies (not treated)

Plants from an underground caudex, offshoots may arise a few inches out (occasionally rhizomatous in *L. arcticus*, but then with long basal petioles, see above).

Banner obovate, often obtuse; stems slender, branching above; racemes primarily south of the Columbia R. ....*L. latifolius* (not treated)

Banner orbicular, wider than long, emarginate; stems hollow, fistulose to slender; plants 2–3 dm tall.

Stems fistulose; lower calyx lip enlarged, boat shaped; secondary branches often slender; pubescence shaggy-lanate (sericeous in *L. nootkatensis* var. *fruticosus*), upper surface of leaflets glabrous or strigose; wings 15–22 mm long; keel ciliate above the claws; maritime or insular Alaska and British Columbia.....2. *L. nootkatensis*

Stems hollow but usually not fistulose; lower calyx lip relatively slender (as in *L. arcticus*); leaflets various but not lanate; wings 12–15 mm long; keel glabrous or ciliate toward the acumen; near timberline, Vancouver I., British Columbia, to montane Washington and Alaska.....3b. *L. arcticus* ssp. *subalpinus*

1. LUPINUS POLYPHYLLUS Lindl., Bot. Reg. pl. 1096. 1827, ssp. POLYPHYLLUS var. POLYPHYLLUS. Type: *Douglas 116* (CGE, Dunn, 1956b). *L. grandifolius* Lindl. ex Agardh, Syn. Gen. Lup. 18. 1835. Type: California?, *Douglas* (Lindley Herb., CGE). *L. polyphyllus* var. *grandifolius* (Lindl. ex Agardh) Torr. & Gray, Fl. N. Am. 1:375. 1840. *L. magnus* Greene, Pittonia 3:160. 1897. Type: not seen, but specimens labeled by Green seen (JEPS, UC). *L. matanuskensis* Smith, Spec. Lup. 651. 1949. Matanuska, Alaska, *Anderson 945* (ISC). *L. pseudopolyphyllus* Smith, Spec. Lup. 650. 1949. Type: Moose Pass, Alaska, *Anderson 6825* (ISC, shows traits of introgression from *L. nootkatensis*). *L. stationis* Smith, Spec. Lup. 651, 1949. Type: Anchorage, Alaska, *Purer 7539* (DS, hybrid to *L. nootkatensis*). *L. polyphyllus* ssp. *polyphyllus* var. *polyphyllus*, sensu Phill., in part, Res. Stud. St. Col. Wash. 23: 180. 1955.

Plants perennial, from a branched caudex, new shoots sometimes arising several inches away from the old stem, subrhizomatous; stems generally unbranched, fistulose, 5–15 dm high, glabrate but sometimes scattered pilose to hirsute hairs present, with a sparse undercoat of minute appressed puberulent hairs, generally only 3–5 cauline nodes, several basal leaves with long petioles; petioles of the lowest normal leaves vary from 1.4–6.2 dm long, gradated upward, with the upper petioles only 6–10 cm long; stipules also gradated, as much as 3.5 cm long basally and only 1 cm long above, with 3–5 mm free at the tip of the lower ones and 5–7 mm free on the upper ones, the remainder of each stipule connate to the petiole; leaflets 11–14 (17) elliptic-oblongate, the tip acute, sometimes acuminate, the largest 5.5–12 cm long, 10–22 mm wide, glabrous above (strigose in *L. polyphyllus* var. *pallidipes*), sparsely strigose below; peduncles 4–14 cm long; racemes 18–40 cm long at maturity, generally verticillate but sometimes scattered, usually dense, the verticils 10–22 mm distant at anthesis; bracts subulate to lanceolate, caducous, 10–13 mm long; pedicels spreading to ascending at anthesis, 5.4–9.4 mm long, filiform, densely to sparsely spreading hispidulose; calyx sericeous to puberulent, the two lips nearly equal, 3.6–7.5 mm long, both entire or with minute teeth, the upper lip with a notch averaging 0.3 mm, the lips connate 0.7–1.5 mm with a flat bracteole 0.4–1.5 mm long at the sinus; banner 11.6–14.8 mm long, 9.6–14.0 mm wide, broadest below the middle, reflexed at the midpoint (reflexed/appressed ratio 1.05), the angle of reflection  $128^{\circ}$ – $154^{\circ}$  (average  $137^{\circ}$ ), the deep sulcus averages 2.1 mm deep at the mid-point along the appressed part of the banner; wings 12.0–15.7 mm long (average 14.1), 6.7–9.8 mm wide (average 8.2); keel 3.7–4.8 mm wide at the middle with a slender arcing acumen, the angle  $68^{\circ}$ – $90^{\circ}$  (average  $82^{\circ}$ ); pods arching, 28–50 mm long, 7–9 mm wide, densely lanate with hairs 2–3.5 mm long; ovules 6–10; mature seeds 2.2–2.8 mm wide, 3.0–3.8 mm long.

The relationships of several characteristics are illustrated (figs. 1–3) showing a random sample of 25 members of each of the three species treated. The characteristics conformation of the floral parts of *L. poly-*



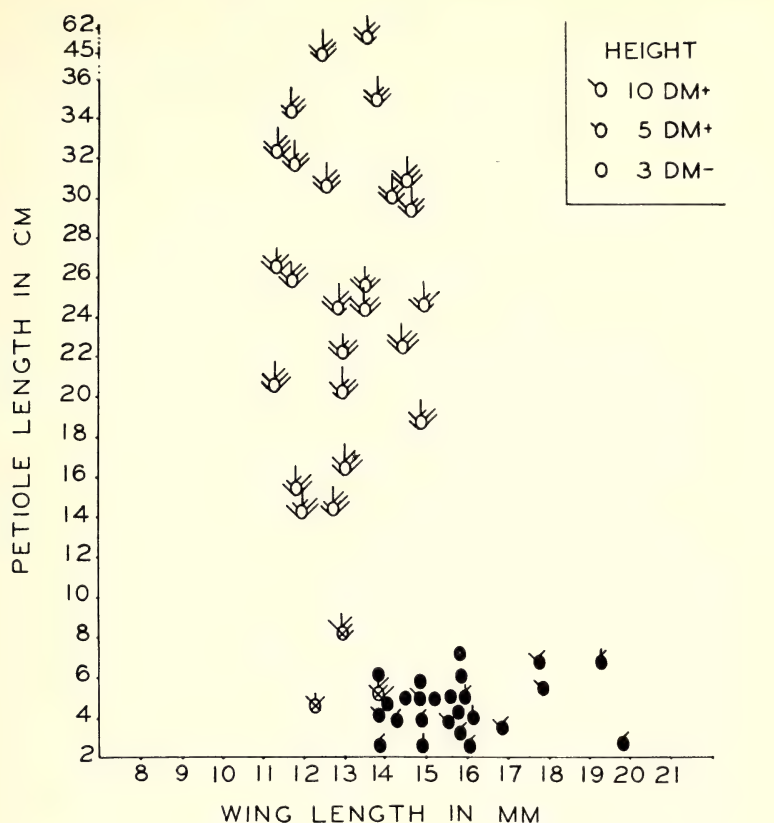
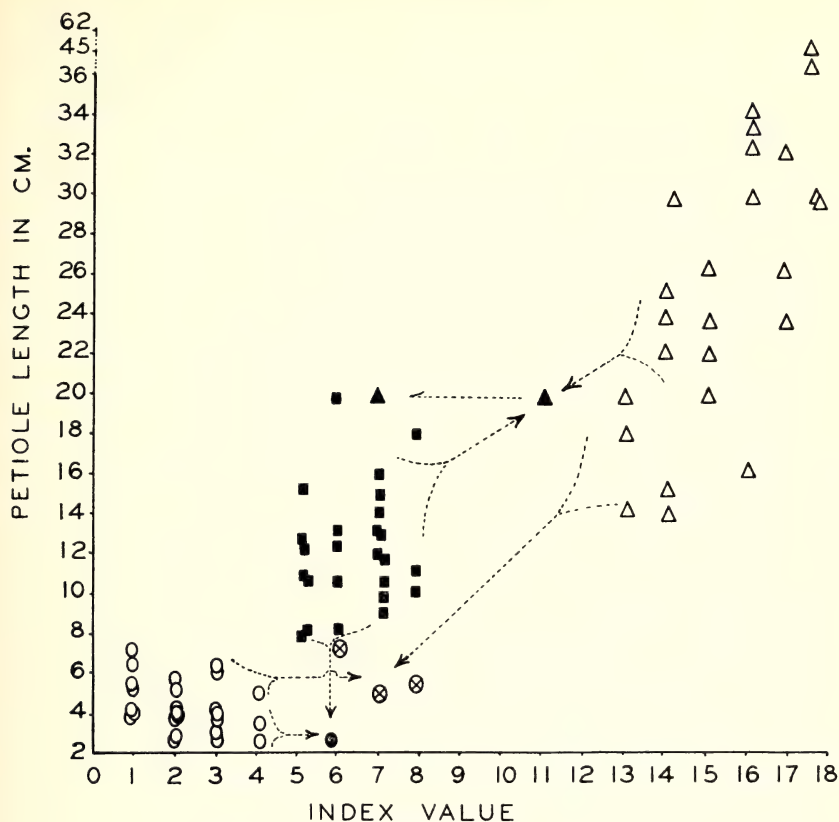


FIG. 2. Scatter diagram comparing *L. polyphyllus*, open glyphs, with *L. nootkatensis*, solid glyphs. Putative hybrids are indicated with a cross in the glyph. Both varieties of *L. nootkatensis* are included among the plants plotted.

*phyllus* is illustrated in Fig. 4-1. The size of each part of the flower was drawn to scale for the mean value of a sample of 25. The range of *L. polyphyllus* (in the strict sense) is shown in Fig. 5. Ecologically the species prefers a wet habitat, commonly occurring in seepage areas or on stream-banks; areas of high rainfall, cool nights, cold winters and the fog belt from northern California to British Columbia. Those specimens from drier sites show introgression or intergradation into subspecific taxa as indicated.

2a. LUPINUS NOOTKATENSIS Donn ex Sims, Bot. Mag. 32: pl. 1311. 1810, var. NOOTKATENSIS. *L. nootkatensis* var. *henry-looffii* Smith, Sp. Lup. 653. 1949. Type: Olga Bay, Alaska, *E. & H. Looff* 667 (DS). *L. nootkatensis* var. *ethel-looffiae* Smith, Spec. Lup. 653. 1949. Type: Alitak Mts., Alaska, *E. & H. Looff* 125 (DS, isotypes at GH, MO, intergrades to *L. nootkatensis* var. *fruticosus*). *L. nootkatensis* var. *perlanatus* Smith, Spec. Lup. 655. 1949. Type: St. Paul's I., Alaska, *Anderson* 4035 (ISC). *L. nootkatensis* f. *leucanthus* Lepage, Am. Midl. Nat. 46: 758. 1951. Type: Kodiak, Alaska, *Lepage* 25223 (LCU, not seen). *L. perensis* ssp. *nootkatensis* (Donn ex Sims) Phill., in part, Res. Stud. St. Coll. Wash. 23: 175. 1955.

Perennial plants, dying back annually to a subterranean woody caudex; stems 4–10 dm tall in favorable locations, barely 10 cm tall in locations of severe exposure such as windswept bluffs, hollow, the larger quite fistulose, 1–1.5 cm in diameter, with abundant pilose hairs, becoming sparser by sloughing off with age; petioles all cauline, all short, 2–10 cm long, seldom twice as long as the leaflets, the longest on the primary stem about midway in height; stipules on lower abnormal leaves up to 6 cm long, connate, except for 6–10 mm of subulate to filiform free tip, upper stipules 1.5–2.5 cm long, connate for only 2–4 mm, woolly with pilose hairs up to 4 mm long; leaflets 5–8, broadly oblanceolate, the tip round, mucronate, shaggy-villous below, generally glabrous above, but sparsely villous near the margins in about 30% of those seen, about 5% were pubescent over the entire upper surface, the largest leaflets from 1.8–6.5 cm long (average 4.17), 4–16 mm wide (average 10.7), the smaller from sites of severe exposure; peduncles 1–9 cm long, longest in fruit; racemes from 2–10 cm, sometimes to 30 cm in favorable sites, 1–15 verticils, sometimes 20, generally less than 10, verticils 15–35 mm distant at anthesis; pedicels 7–13 mm long, pilose; bracts 16–19 mm long, filiform, convolute, caducous; lower lip of calyx 7.6–11.5 mm long, broad, boat shaped, bent backwards, deeply toothed at the apex, woolly without and sericeous over most of the inside; upper calyx lip deeply two lobed the notch 0.4–2.7 mm deep, lobes 6–9 mm long, woolly outside, sericeous inside, the lips connate 1–1.4 mm. bracteole at the lip of the sinus attached midway or basal, filiform, 1.7–5.0 mm long, woolly with long pilose hairs; banner 12.5–19 mm long, 14.0–21.4 mm wide (length/width ratio 0.85) broadest below the middle, reflexed part 7.4–10 mm long, appressed part 6–9 mm, the sulcus 1.5–2.7 mm deep midway along the appressed part, angle of reflection  $112^{\circ}$ – $141^{\circ}$  (average  $129^{\circ}$ ); wings 14–20 mm long, 8.3–11.0 mm wide (average 10); keel 4.0–6.0 mm wide at middle, ciliate along upper edges, the angle curvature  $82^{\circ}$ – $95^{\circ}$  (average  $90.4^{\circ}$ ); ovules 7–11 (average 9.4); mature pods 5–6 cm long, 10–12 mm wide, arcing up and outward, lanate when young but most sloughing off the sides, thinly sericeous when seeds are shed, black in age; seeds 4.6–5.0 mm long, 2.5–3.0 mm wide, scar of the funiculus large and subterminal, leaving a deep hole in seed coat, from black to light, mottled.



$\Delta$  = *LUPINUS POLYPHYLLUS*;  $\blacksquare$  = *L. ARCTICUS*;

$\circ$  = *L. NOOTKATENSIS*;  $\blacktriangle, \bullet, \otimes$  = HYBRIDS ?

FIG. 3. Scatter diagram of all three species and their putative hybrids. Values on the abscissa represent the sum of the index values plotted in Figs. 1, 2. Dotted line arrows indicate how the putative hybrids fall in between the taxa being compared. Position of the glyph for one putative hybrid between *L. arcticus* and *L. polyphyllus* suggests that it represents backcrossing to *L. arcticus*.

The habitat of this species is essentially maritime (fig. 6). It occupies coastal areas in Alaska and British Columbia and the Aleutian I. chain. Its southern limit appears to be Vancouver I. It has been introduced into Newfoundland, Nova Scotia, and Scotland. It has the most westerly natural distribution of any species in the genus.

In addition to the relationships discussed in the introduction of this paper pertaining to *L. polyphyllus* and *L. arcticus*, *L. nootkatensis* combines or shares characteristics from several taxa with which it currently does not share any geographic range. *Lupinus arboreus* has a maritime

habitat, the boatshaped lower calyx lip, large flowers of similar conformation, ciliate keel toward the acumen and short petioles in common. *Lupinus latifolius* has fistulose, herbaceous stems, the same shaped leaflets and a ciliate keel above, near the claws, in common. These characteristics in common may be interpreted as sources of the genetic traits in the present day material recognized as *L. nootkatensis*, or that these several taxa had ancestors in common, in part. Natural hybrids occur between *L. nootkatensis* and several other species as discussed above (figs. 2, 3) and it has characteristics from several of these. It has a rather well defined geographic range and a genome which has become adequately established to consider this taxon as a species.

Two unusual specimens were noted *Dorwart* 32 (ISC) from Adak I. and *Glassberg* 980 (ISC) labeled "Alaska." These two specimens are virtually identical in their morphological traits and if they did not come from the same population they constitute a variant which could require a name. The difference between these specimens and typical *L. nootkatensis* is greater than that between var. *fruticosus* and var. *nootkatensis* and there have been several names applied to each of these varieties. *Lupinus kiskensis* Smith may be similar material. The stems are more slender and covered with hirsute straight spreading hairs about 1–2 mm long, instead of soft lanate hairs 2–4 mm long; the leaflets are narrowly oblanceolate, obtuse, mucronate, 2–3.5 cm long, 5–7.5 mm wide, sericeous beneath and appressed strigose to pilose hairy above; the peduncle is 2–5 cm long; the raceme is dense with scattered flowers; bracts caducous; pedicels 6–10 mm long, densely villous; the lower calyx lip is slightly reflexed, boat shaped but not as large as typical *nootkatensis*; the flowers are 13–15 mm long, which is small for *nootkatensis* and the veins are dark and darken further with age; the petals are glabrous including the keel, except for minute papillae above and below the claws as found in *L. polyphyllus* ssp. *superbus* and occasionally in typical *polyphyllus*. The appearance of these plants could be accounted for if they were hybrids between *L. kuschei* from northern British Columbia and southern Yukon and *L. nootkatensis*. However, Adak I. is so far from the nearest stations known for *L. kuschei* that this hypothesis seems unlikely.

2b. *LUPINUS NOOTKATENSIS* var. *FRUTICOSUS* Sims, Bot. Mag. 47: pl. 2136. 1820. *L. nootkatensis* var. *glaber* Hook., Fl. Bor. Am. 1:163. 1834. *L. nootkatensis* var. *unalaskensis* Wats., Proc. Am. Acad. 8:524. 1873. Lectotype: designated by previous authors, *Harrington*, 1871 (GH). *L. perensis* ssp. *nootkatensis* (Donn ex Sims) Phill., in part, Res. Stud. St. Coll. Wash. 23: 175. 1955.

Stems slender, the primary hollow, to 6–7 mm in diameter, the upper branches 1.5–2.5 mm in diameter, finely appressed silky sericeous throughout, except the upper surface of the leaflets generally glabrous, about  $\frac{1}{3}$  were sparsely strigose above near the margin; stipules shorter than in *L. nootkatensis* var. *nootkatensis* and sericeous; pedicels hispidulose, bracts 7–13 mm long, sericeous and generally flat and subulate; lower



calyx lip the same shape but with smaller teeth and sericeus inside and outside; the upper lip the same as the species but sericeus on both sides; bracteole shorter and sericeus; the remaining parts of the flower are not distinct from the species.

The original description stated a sub-shrubby plant, which has led most authors to question the identity. The plants indeed appear sub-shrubby in vigorous specimens, particularly in locations mild enough to permit secondary and tertiary branches to flower. These later flowering branches often have only a few verticils. The floral structures in nature are clearly conspecific. The sericeus nature of the pubescence and the shape of the pods, and the number and shape of the seeds, as well as the short petioles are characteristics which occur in both *L. littoralis* and *L. arboreus*. *Lupinus littoralis* is the northernmost representative of the subshrubby *L. arboreus* complex and it occurs on the north end of the Queen Charlotte Islands in proximity with *L. nootkatensis*. The above traits are diffused throughout the species, so that var. *fruticosus* is completely sympatric with var. *nootkatensis* (fig. 6) and the genome for the sericeus condition and the more slender stems appears intermittently. Late season growth of var. *nootkatensis* may resemble var. *fruticosus* in general absence of lanate hairs by the sloughing of the long hairs; however, there are usually some areas on the stem with residual patches of long hair.

Watson (1873) placed var. *fruticosus* in *L. littoralis*. The original illustration does show some characteristics of *L. littoralis*. As noted above *L. nootkatensis* has several characteristics which are in common with or derived from *L. arboreus*. In the original description of var. *fruticosus*, Sims wrote: "Communicated by MR. ANDERSON from the Chelsea garden, where it was introduced by MR. LEE, of the Hammersmith Nursery, who informs us it was first raised in Somersetshire from seed of LUPINUS *perensis* or *nootkatensis*, with the latter of which particularly it appears to have a very near affinity." Since the name was applied to a plant of garden origin, which quite obviously had *L. nootkatensis* as the female parent (both taxa mentioned are herbaceous in nature) I would suggest that the nursery had material of *L. arboreus* growing nearby, available as the male parent. *Lupinus arboreus* had already been introduced and described in England. I have personally succeeded in crossing *L. arboreus* with several other shrubby lupines from California, using it as the male parent, but all attempts using *L. arboreus* as the female parent failed.

3a. LUPINUS ARCTICUS Wats., Proc. Am. Acad. 8:526. 1873, ssp. ARCTICUS. Lectotype: Bear Lake, *Richardson* (GH, specimen formerly in herb. Hookerianum), designated by Eggleston. *L. nootkatensis* var. *kjellmannii* Ostf., Vidensk.-Selsk. Skr., Math.-Naturv. Kl. 8. 1910. Type: King Pt., Yukon, *Ostenfeld*, 1908 (not seen, location excludes all other taxa). *L. borealis* Heller, Muhlenbergia 8:82. 1912. Type: Klondike R., Yukon, *Macoun 58426* (RENO). *L. yukonensis* Greene, Leaflet Bot. Obs. 2:233. 1912. Type: Klondike R., Yukon, *Macoun 58426* (ND). *L. gakoensis* Smith, Spec. Lup. 649. 1949. Type: Gakona, Alaska, *Anderson*

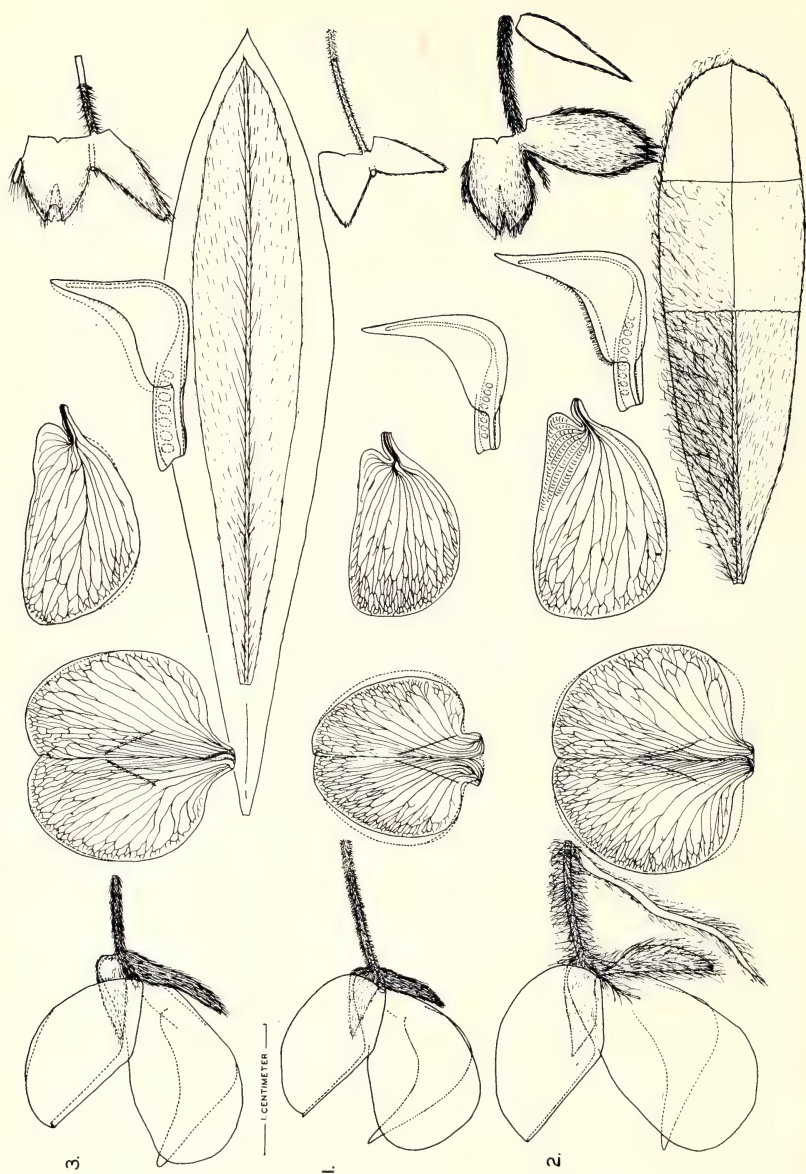


FIG. 4. Floral and leaflet characteristics of: 1, *L. polyphyllus*, 2, *L. nootkatensis*, and 3, *L. arcticius* ssp. *arcticus*. Drawings are based on the mean values of a random sample of 25 plants. Floral measurements were made as described by Dunn (1954). Floral parts from top to bottom are: ventral view of the unfolded calyx cut along the left lateral sinus; side view of keel; side view of wing; banner flattened; and side view of intact flower. Dissected calyx in the right row illustrates the different pubes-

8532 (ISC). *L. multicaulis* Smith, Spec. Lup. 649. 1949. Type: Glenn Highway, Alaska, *Anderson*, 1944 (ISC). *L. donnellyensis* Smith, Spec. Lup. 654. 1949. Type: Richardson Highway, Alaska, *Anderson* 2281 (ISC). *L. multifolius* Smith, Spec. Lup. 660. 1949. Type: Lake Kluane, Yukon, *Anderson* 9449 (ISC). *L. relictus* Hult., Fl. Alaska and Yukon 7:1074. 1947, in synon. *L. polyphyllus* ssp. *arcticus* (Wats.) Phill., in part, Res. Stud. St. Coll. Wash. 23:181. 1955.

Plants perennial, dying back to an underground branched, woody caudex; stems clustered 2–4 dm tall at anthesis elongating more as the fruit develops, pubescence thinly silky sericeous, appressed or with few to numerous spreading pilose hairs; petioles of the early leaves very stunted at northern latitudes on overwintering radical shoots of the previous season, while new radical shoots develop the longest petioles at the base of the plants, radical shoot with petioles 9–15 cm long, apparently developing flowering culms after one or more years growth as a radical shoot; stipules variable, subulate to setaceous in the free portion, the connate portion up to 3 cm long on basal leaves; leaves all dying back to ground level annually; leaflets 6–10, elliptic-oblongate with an acute, mucronulate tip, glabrous above, thinly strigose below, 2.5–5 cm long and 7–9 mm wide at anthesis, becoming 10–15 mm wide and up to 9 cm long at fruiting time or in favorable habitats; peduncles 4–7 cm long; racemes generally 5–8 cm long occasionally to 15 cm long; 3–7 verticils, 12–18 mm distant at anthesis; bracts, subpersistent to caducous, setaceous, 8–15 mm long; pedicels filiform, 4–6 mm long at anthesis, fine pilose spreading hairs 0.5–1.0 mm long; calyx strigose to villous, the lower-lip 6.5–10.8 mm long, slender lanceolate arcing down, the upper-lip quite gibbous at the base, 4.7–8.2 mm long, the notch 0.3–2.7 mm deep, the lateral sinus-bracteole 0.4–3.0 mm long attached at the base, midway up or at the lip of the sinus notch between the lips of the calyx; banner orbicular 13.8–19 mm wide (average 15.8), 13.8–17.3 mm long (average 15.2), length width ratio 0.96, reflexed at about the midpoint, average 7.8 mm reflexed and 7.6 mm appressed, reflexed appressed ratio 1.026, the angle of reflection  $107^{\circ}$ – $142^{\circ}$  (average  $124.5^{\circ}$ ); wings 14.2–18.7 mm long, 7.2–9.0 mm wide; keel 3.5–5.0 mm wide at the mid-point, the angle  $82^{\circ}$ – $96^{\circ}$ , glabrous or sparsely ciliate above toward the acumen; ovules normally 5–8 (average 7); mature pods 43 mm long, 9 mm wide, silky-lanate.

Of the four specimens available to Watson when he described this species two were formerly in Herbarium Hookerianum and apparently were exchange material obtained from a British voyage along the arctic

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cence and the bract of *L. nootkatensis* var. *fruticosus*. Large leaflet outline is of typical *L. polyphyllus*. Lower surface of the typical leaflet of *L. arcticus* is drawn within the outline of a *L. polyphyllus* leaflet. Typical leaflet of *L. nootkatensis* is drawn in the right row, with the lower half as the bottom surface. Variation in the pubescence of the two varieties is illustrated for both surfaces, with *L. nootkatensis* var. *fruticosus* as the right half.

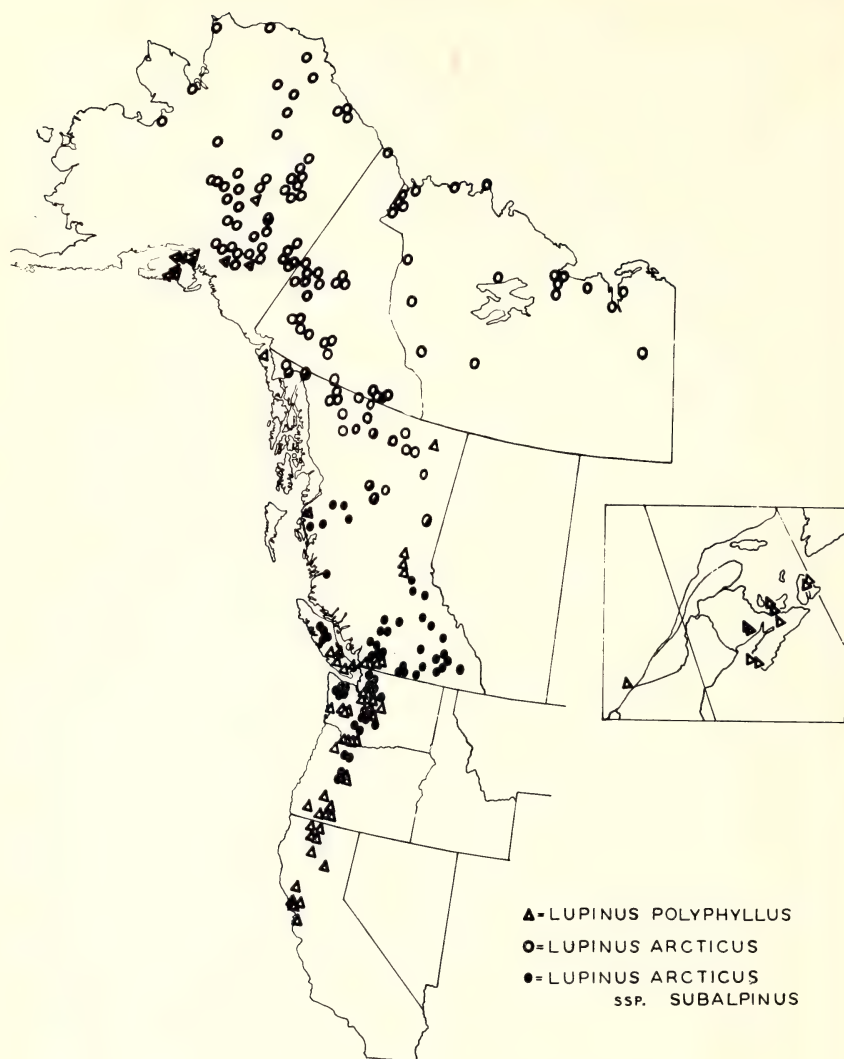


FIG. 5. Distribution of *L. polyphyllus* and *L. arcticus* in western North America. *Lupinus polyphyllus* has been introduced in to eastern Canada as is shown by the insert. Half shaded circles indicate *L. arcticus* intermediates, see text.

coast of the Northwest Territories. Present day material most closely matching the Polar Sea specimen of Dease and Simpson is from the vicinity of Bathurst Inlet, south of Dease Strait. Both of these specimens, used by Watson, were from the vicinity of the Arctic Circle. The other two specimens included: Vancouver I., *Wood*; and Washington Territory, *Lyll*, both from the southern end of the range of ssp. *subalpinus*. Wat-



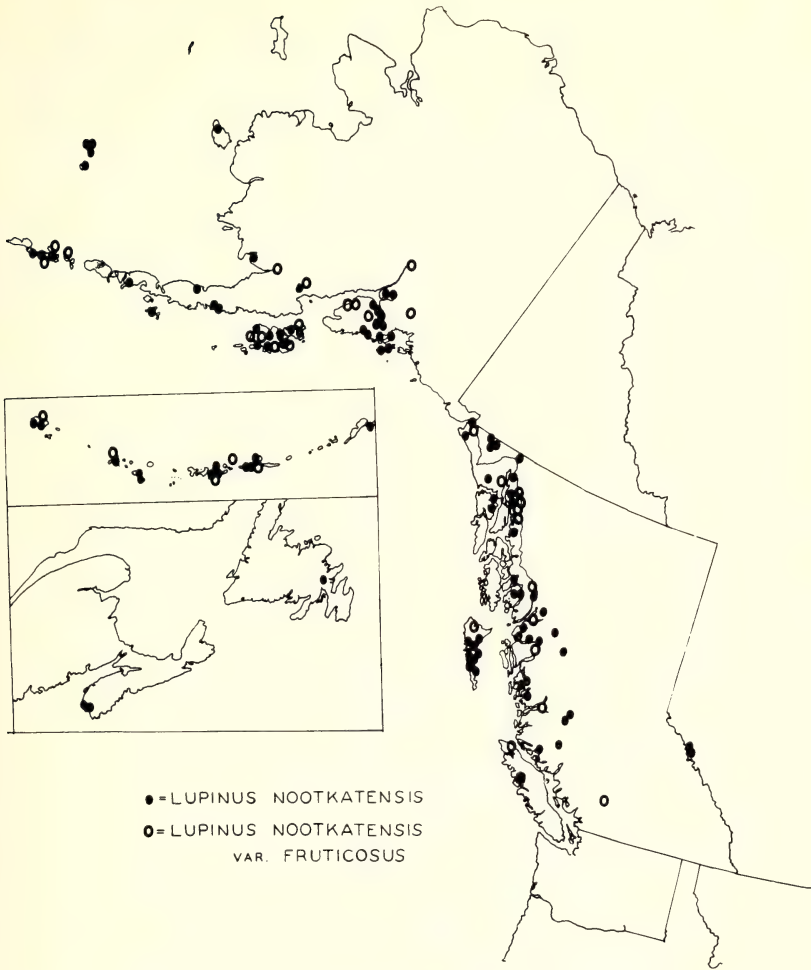


FIG. 6. Distribution of *L. nootkatensis* in western North America. It has been introduced into eastern Canada as is shown by the insert.

son's statement "and probably all the *L. perennis* from the Arctic Coast," clearly suggests that Eggleston's selection of the arctic specimen as the type complied with Watson's intention.

The typical material is thus on the arctic slopes extending upward into the montane areas in Alaska and Yukon but primarily on the mounds in the relatively flat tundra regions. The montane material in both areas has smaller flowers, is more erect, and has more cauline leaves. The latter character may have been acquired from *L. nootkatensis* but the habitat is generally not allied, nor is the floral conformation. The smaller flowers

could have come from *L. kuschei* in the Carcross area in southern Yukon and several hybrids are cited but *L. kuschei* is itself a "stabilized" entity derived from a few *L. arcticus* characters, blended with primarily *L. sericeus* characters. The smaller flowered ssp. *subalpinus* with cauline leaves extends southward in British Columbia and into Washington, in areas near permanent snow. Subspecies *subalpinus* extends far southward into the range of *L. polyphyllus* but occurs at higher altitudes in the south and in a very different habitat. I have not been able to find any indication of a transition between the two, suggesting that free gene exchange does not occur. Since only occasional isolated hybrids have been found (fig. 1) and each has a distinct distribution pattern (fig. 5), I consider *L. arcticus* and *L. polyphyllus* to be ecospecies, which introgress only occasionally. The greatest affinity of *L. arcticus* is with *L. perennis* and from which it is isolated by a distance of over 1000 miles.

3b. LUPINUS ARCTICUS ssp. **subalpinus** (Piper & Robins.) Dunn, comb. nov. *L. subalpinus* Piper & Robins., Contr. U.S. Nat. Herb. 11:356. 1906. Type: Cascade Mountains to Fort Colville, Washington, *Lyall*, 1860 (GH). *L. latifolius* var. *subalpinus* (Piper & Robins.) Smith, Bull. Torrey Club 51:308. 1924. *L. arcticus* var. *subalpinus* (Piper & Robins.) Smith, in Abrams, Ill. Fl. Pac. States 2:518. 1944. *L. glacialis* Smith, Spec. Lup. 236. 1940. Type: Snohomish Co., Washington, *Thompson* 14705 (DS). *L. volcanicus* var. *rupestricola* Smith, Spec. Lup. 236. 1940. Not *L. volcanicus* Greene. Type: Lewis Co., Washington, *Thompson* 15210 (DS). *L. latifolius* var. *canadensis* Smith, in part, Bull. Torrey Club 51:307. 1924.

The leaves all cauline; the longest petioles 4–8 cm long, lower and middle; leaflets narrowly oblanceolate, acute to obtuse or rounded and mucronate at the tip, generally glabrous above and strigose beneath but often also sparsely strigose above; racemes commonly with 4–6 verticils but occasionally more; flowers generally smaller than the species but generally with the same conformation, smallest in the areas of montane Washington; ciliation may occur on the lower edge of the wings, as well as along the entire length of the upper edge of the keel or only along parts of the upper edge, often reduced to minute papillae above the claws of the keel.

This subspecies combines the cauline leaf trait and the rounded tips of the leaflets in a percentage of the population, from *L. nootkatensis*, as well as ciliation characters of the keel, with floral and leaf character and habitat preference of *L. arcticus*. In addition the smaller flowers may have been acquired by introgression from *L. kuschei* of the *L. sericeus* complex. The more southerly range suggests that daylength factors have also been acquired, probably through introgression. I consider the specimen from Needles, British Columbia, *Calder & Savile* 10100 (DAO) to be a hybrid between *L. argenteus* and *L. arcticus* ssp. *subalpinus*, while a second specimen from Edgewood, British Columbia, is primarily *L. arcticus* ssp. *subalpinus* with introgression from *L. argenteus*. Hybrids

with *L. polyphyllus* or *L. nootkatensis* are obvious but the transition into *L. arcticus* appears complete in the montane areas in Alaska, Yukon and British Columbia. Hence, the contention that this taxon is primarily a derivative of *L. arcticus*. To the south, this taxon does not form a bridge or connecting link with *L. polyphyllus* as Phillips' (1955) treatment would suggest but instead it appears to be more closely connected with *L. latifolius* and *L. rivularis* of Washington, Oregon, and California. The best break in the maze of inter-acting taxa appears to be in the Columbia River area. The glacier margin or arctic-alpine habitat of ssp. *subalpinus* suggests that both it and *L. arcticus* form a northern ecospecies, while *L. nootkatensis* forms a maritime ecospecies, and *L. latifolius* a related and connected southern ecospecies, which also has multiple derivatives, as evidenced by the numerous names that have been applied to the latter complex.

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#### NOTES AND NEWS

THE MICHIGAN BOTANIST.—For a limited time, back volumes of *The Michigan Botanist* will be available to new subscribers at a reduced rate. New subscribers to Volume 4 (1965) at the regular rate of \$2.00 per year may obtain a complete set of Volumes 1-3 (1962-1964), including a detailed 3-year index, for \$4.00. To qualify for this special reduction, orders with remittance for total of \$6.00 must be received prior to March 15, 1965, by the business manager, Mrs. Laura Roberts, 2120 Washenaw Rd., Ann Arbor, Michigan.

Published four times per year by the Michigan Botanical Club, this journal is devoted to all phases of botany in the Great Lakes region, and has included major articles on vascular plants, fungi, bryophytes and lichens, and exploration. Articles have been included on ecology, phytogeography, taxonomy, morphology, and technique, as well as annotated bibliographies and lists of new literature and maps.

## THE TRIBE ORCUTTIEAE AND THE SUBTRIBES OF THE PAPPOPHOREAE (GRAMINEAE)

JOHN R. REEDER

In the days when grasses were classified on the basis of gross morphological features alone, the placement of the annual California endemics, *Orcuttia* and *Neostapfia*, presented few problems to the agrostologist. Vasey (1886), who described *Orcuttia*, assigned it confidently to the tribe Festuceae, subtribe Seslerieae. *Neostapfia* likewise was considered a member of this tribe by its discoverer (Davy, 1898), but he assigned it to a different subtribe, the Meliceae. The genus was originally described as *Stapfia*, but this name was "stillborn" since it is a homonym of *Stapfia* Chodat (1897). In the following year, Davy (1899) renamed his new genus *Neostapfia*. The structure of the spikelet in these genera would suggest that their alliances are, indeed, with the Festuceae. In both, the spikelets are more or less laterally compressed, consist of several to many florets, and the glumes and lemmas are of a similar texture. The most recent floras which treat the California grasses (Hitchcock, 1950; Mason, 1957; Munz, 1959) still follow this placement.

*Neostapfia* is monotypic, whereas *Orcuttia* is known from 5 species and two varieties. Both genera are restricted to a special type of vernal pool or "hog wallow" within the Great Valley of California. Thanks to the work of Hoover (1941) and more recently Crampton (1959), a great deal is now known about the habitats and ecology of these rare but interesting grasses. Hoover's work on *Orcuttia* is largely taxonomic, and he includes a key to the four species and two varieties then known. Although he explored no further than gross morphology, he allowed himself the luxury of speculation regarding relationships. He states that the phylogeny of *Orcuttia* is obscure, but that it is obviously related to *Neostapfia*. He indicates no dissatisfaction with the placement of these genera in the Festuceae, but believes that it is a fallacy to relate them to *Pappophorum*. He makes the rather remarkable statement: "I am inclined to believe that *Pleuropogon* is involved in the ancestry of *Orcuttia* and *Neostapfia*."

Crampton (1959) also believes that *Orcuttia* and *Neostapfia* are closely related, but he states correctly that they do not belong with the Festuceae. He believes that they are without a doubt the most unusual and rarest of the California grasses. He indicates that: "Their relationship to other grasses is not apparent and quite likely they represent a relict group, the ancestors of which are unknown." He feels that they should be removed from the Festuceae and might well be considered as a separate tribe. Stebbins and Crampton (1961) include these two genera in the tribe Pappophoreae, associated with *Pappophorum*, *Enneapogon*, and *Cottea*.

The present paper is a review of the characteristics of these two unusual genera along with new information, particularly from the caryopsis



and embryo.<sup>1</sup> Comparison is made with typical members of the Pappophoreae, their apparent closest allies.

As Crampton (1959) has pointed out, the caryopses are more or less strongly laterally flattened in both *Orcuttia* and *Neostapfia*, and the hilum is rather conspicuous. Grains of *Neostapfia* are obovate and dark brown, whereas those of *Orcuttia* are oblong and somewhat translucent. In both genera the embryo is narrow and nearly as long as the seed. A noteworthy feature is that the base of the caryopsis is largely endosperm, the slender lower portion of the embryo occupying only a very small area (figs. 1-3). In members of the Pappophoreae, the caryopses are dorsally compressed or nearly circular in cross-section, the hilum is punctiform, and the lower part of the grain is made up almost entirely of the embryo (figs. 4-6).

Embryos of *Orcuttia*, *Neostapfia*, and members of the Pappophoreae are, in most respects, rather similar (figs. 7-16). In longitudinal sagittal section it can be seen that 1. the coleoptile is inserted at some distance above the point of divergence of the scutellar trace, and that there is a distinct "internode" between coleoptile and scutellum, 2. the lower part of the scutellum is free from the coleorhiza, there being a distinct cleft between the two, and 3. usually an epiblast is present, although in some species of *Orcuttia* it may be very small or lacking altogether. Evidence from the embryo thus supports strongly removal of all of these genera from the Festuceae, and even from the subfamily Festucoideae (Reeder, 1957).

A more critical study of the embryos reveals that those of *Orcuttia* and *Neostapfia* share certain features which are not found among members of the Pappophoreae. In the former, the embryos are rather slender, the "internode" is often unusually long, and the tip of the coleoptile is greatly elongated and composed of solid tissue (figs. 7-11). It may also be of significance that the shape of the scutellum, as seen in transection, in embryos of *Orcuttia* and *Neostapfia* is rather different than in members of the Pappophoreae.

The leaf epidermis in grasses often is a source of characters which are of significance in systematics. In connection with the present study, leaves of *Neostapfia*, all species of *Orcuttia*, and representatives of *Pappophorum*, *Cottea*, *Enneapogon*, *Schmidtia*, and *Kaokochloa* were examined. It has been pointed out by Metcalfe (1960) and Stebbins and Crampton (1961) that both *Neostapfia* and *Orcuttia* have characteristic bicellular microhairs which apparently are not found among members of any other grass genus. In this investigation, these "mushroom-button" microhairs (figs. 17, 18) were found to be present in all species of *Orcut-*

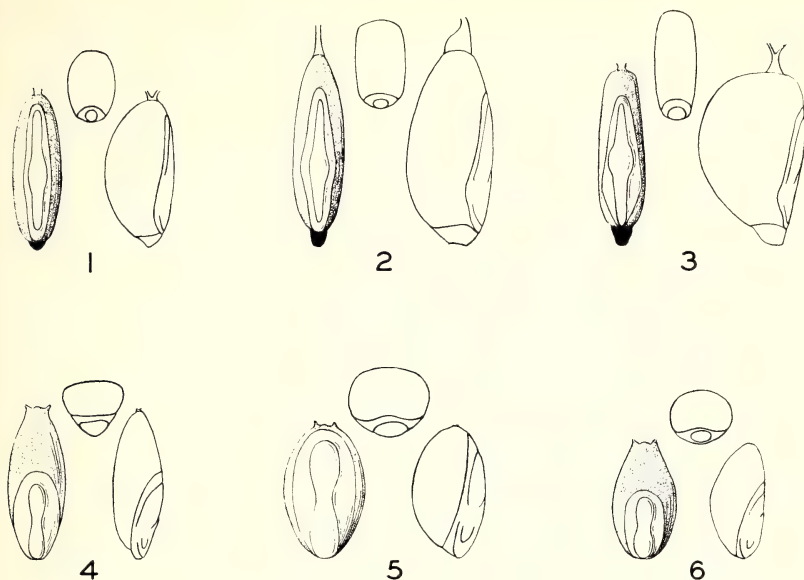
<sup>1</sup> This research was supported in part by Grant G-9070 from the National Science Foundation. I am indebted to Beecher Crampton for seeds and specimens of *Orcuttia* and *Neostapfia*, to Margaret E. Speer for technical assistance, to Chester F. Natunewicz for help with the Latin diagnoses, and to my wife, who prepared the illustrations and assisted in numerous other ways.

*tia* and also in *Neostapfia*. These unusual hairs are correctly illustrated by Metcalfe, but the figures in Stebbins and Crampton are quite inaccurate. In the latter work, the terminal cell is shown much too large, and the hair appears to have no base, but to emerge from between two regular epidermal cells. Actually, each hair arises from a more or less cubical cell which is only slightly narrower than others with which it is associated. In addition to the bicellular hairs discussed above, the epidermis of *Neostapfia* bears distinctive "crozier hairs" which seem to be unique. The stomata in both *Neostapfia* and *Orcuttia* are very similar and appear somewhat unusual. Rather than the lozenge shape (figs. 19, 20) which is common among non-festucoid grasses, these are often as broad, or even broader, than long. In *Orcuttia* siliceous cells are irregular in outline, some of them being rather distinctly dumbbell-shaped. No siliceous cells were found in *Neostapfia*.

The evidence presented above leaves little doubt that *Neostapfia* and *Orcuttia* are very closely related. Moreover, it is equally apparent that their affinities are not with members of the Festucoideae, but rather with the Eragrostoideae. As to a more precise placement, the only suggestion made thus far is the one by Stebbins and Crampton (1961), who include them with the Pappophoreae. In view of the differences already discussed, the assignment of *Orcuttia* and *Neostapfia* to the tribe Pappophoreae would not appear to constitute a particularly natural alliance. In Pappophoreae the caryopses are dorsally compressed, the hilum is punctiform, and the lower part of the broader embryo constitutes the base of the seed. We may add that the testa in *Orcuttia* and *Neostapfia* is rather loose, a characteristic which has not been noted among members of the Pappophoreae. The embryo itself shows distinctive features, the most noteworthy being the elongated solid coleoptilar tip in members of the former two genera. The epidermis of the leaf has rather distinctive stomata, and microhairs which appear to be unique.

Not only do *Orcuttia* and *Neostapfia* differ rather sharply from members of the Pappophoreae in the features discussed above, but they are quite different morphologically as well. Plants of both genera are short-lived annuals of very restricted ranges, and they occupy distinctive habitats. The leaves are liguleless, there being no sharp distinction between sheath and blade. Although the lemmas are many-nerved, the nerves ordinarily do not extend into prominent awns, as in members of the Pappophoreae. In view of these differences, it appears to the writer that a more natural arrangement would be achieved if *Orcuttia* and *Neostapfia* were treated as constituting a distinct tribe. This is described below:

**Orcuttieae** Reeder, tribus nova. Gramina annua, viscida; foliis eligulatis, sine distinctione in laminas et vaginas; spiculis plurifloris; lemmatibus multinerviis (plerumque 9–15); caryopsibus e latere compressis, hilo in basi amplo, embryone  $\frac{3}{4}$  vel plus longitudine caryopsidis; epidermide foliorum cellulis siliceis nullis vel irregulariter- vel halteriformis; micropis bicellulariis parvis, immersis, fungiculiformis.



FIGS. 1-6. Caryopses in three views: left, face view; right, median sagittal section; above, transection through the coleoptile region: 1, *Orcuttia pilosa*,  $\times 20$ ; 2, *O. mucronata*,  $\times 20$ ; 3 *Neostaffia colusana*,  $\times 15$ ; 4, *Pappophorum mucronulatum*,  $\times 20$ ; 5, *Enneapogon desvauxii*,  $\times 30$ ; 6, *Cottea pappophoroides*,  $\times 20$ . Note in Figs. 1-3 (Orcuttieae) that the caryopses are laterally flattened, the lower part of the embryo barely reaches the base of the seed, and that there is a large basal hilum; in Figs. 4-6 (Pappophoreae) the caryopses are dorsally flattened or nearly circular in transection, and the lower part of the embryo constitutes the base of the seed.

Plants annual, viscid, leaves liguleless, without distinction into sheath and blade, spikelets several- to many-flowered, lemmas many-nerved (mostly 9-15), caryopses laterally flattened, hilum large, basal, embryo three-fourths or more the length of the caryopsis; siliceous cells of the epidermis absent or irregular to dumbbell-shaped, bicellular microhairs small, sunken, "mushroom-button" shaped.

Included genera: *Orcuttia* Vasey; *Neostaffia* Davy.

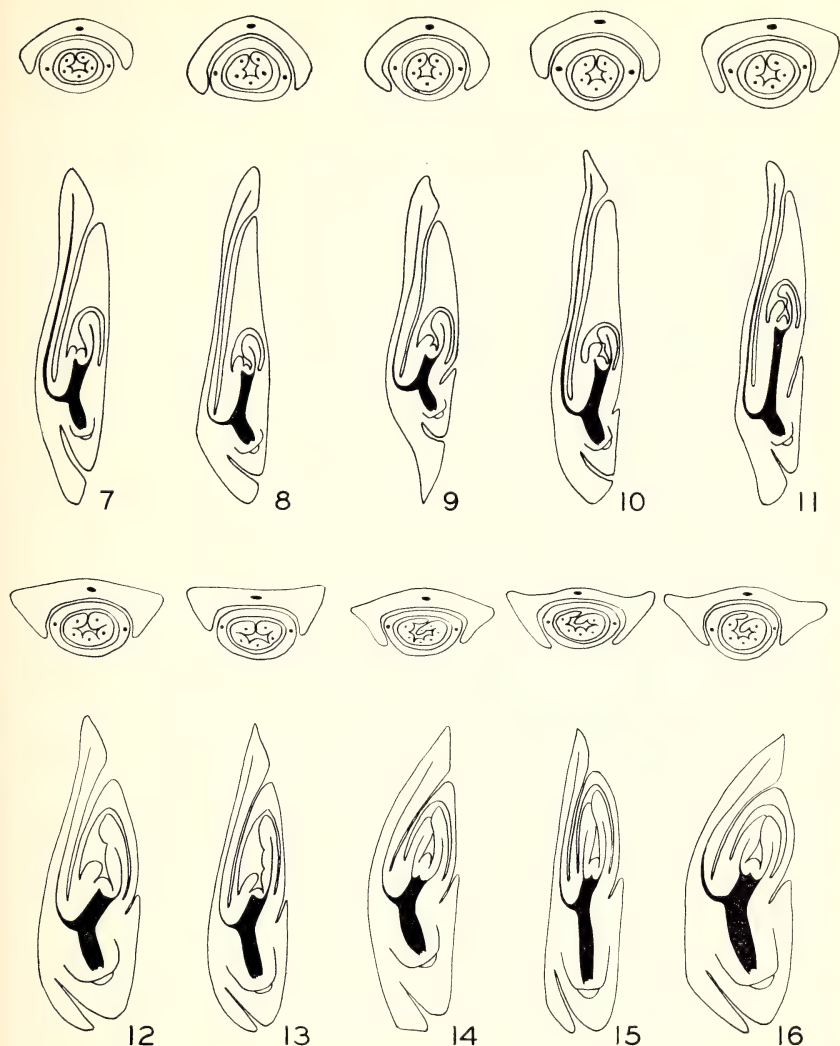
*Neostaffia* thus far is known from a single species, *N. colusana*. Hitchcock (1950) recognizes 4 species of *Orcuttia*, one of which, *O. californica*, consists of 2 varieties in addition to the typical form. The recently described *O. mucronata* (Crampton, 1959) brings the total number of commonly recognized species to 5. Two of these, *O. pilosa* and *O. tenuis*, are so similar to *O. californica* in spikelet morphology that it might be more realistic to treat them as varieties of that species. Until more is known concerning these taxa, both cytologically and genetically, however, it is perhaps most prudent to accept the standard treatments.



The literature on *Orcuttia* usually states that the rachilla is continuous or that the spikelet does not disarticulate between the florets. In this study it was found that when dry, the spikelets, indeed, do not break up. However, when fully mature, the florets readily break apart when soaked in water. This may be an adaptation of considerable importance to these species. During the time that the pools or "hog wallows" are dry, the florets remain on the plants and are thus not blown away by the wind. When the area becomes flooded, the spikelets readily disarticulate and the seeds are thus free for dispersal.

Two genera of grasses which appear to be similar ecologically to the Orcuttieae are *Crypsis* and *Heleochloa*. Lorch (1962), as the result of a critical study, has reunited these under *Crypsis*. He states: "*Crypsis* shows a very striking preference for localities swamped or at least temporarily inundated during winter, and its adaptation to such habitats where it often becomes a dominant component of the summer vegetation." In California, where they have been introduced, members of this genus are often found growing with the Orcuttieae. It is rather curious, moreover, that the caryopses and embryos of *Orcuttia* and *Crypsis* are very similar. We have examined *C. niliaca* and *C. schoenoides* (*Heleochloa schoenoides*) and find the caryopses in both to be laterally flattened, and to have an embryo nearly as long as the seed. These embryos have the same form as those of the Orcuttieae, even to the elongate solid coleoptilar tip. The leaf epidermis of *Crypsis*, however, bears normal eragrostoid hairs. Since the gross morphology is also quite different in *Crypsis*, the similar caryopses and embryos are probably best construed as evidences of parallelism, perhaps conditioned by the environment, rather than as suggesting close genetic affinity.

The tribe Pappophoreae is generally recognized by present-day agrostologists as comprising the genera *Pappophorum*, *Cottea*, *Enneapogon*, and *Schmidtia*. In the older systems, the group was treated as a subtribe of the Festuceae, and this placement is followed in many manuals even today. Prat (1935) studied the leaf epidermis of representatives of the first two genera and concluded that they should be removed from the Festuceae and transferred to the subfamily Panicoideae. He was much impressed with elongate bulbous-tipped hairs which he found in *Cottea*, and indicates that they are similar to those seen by Lohaus (1905) in *Pappophorum commune* F. Muell. Prat states that this indicates a close relationship between *Cottea* and *Pappophorum*. Actually, the plant which Lohaus studied was a species of *Enneapogon*, since the genus *Pappophorum* is confined to the Americas (Chase, 1946). A note under *P. commune* F. Muell. in Chase and Niles (1962) states: "A group name for all the Australian species, the 4 of R. Br., 3 of Lindley, and *P. coerulescens* Gaud. = *Enneapogon*." Prat indicates that this unusual type of hair is pluricellular, but this is certainly incorrect. Caceres (1958) studied the Pappophoreae of Argentina, and reported similar hairs in both *Enneapogon* and *Cottea*. He states emphatically, however, that these hairs are



FIGS. 7-16. Embryos in median sagittal section and transection through the coleoptile region: 7, *Orcuttia californica* var. *inequalis*; 8, *O. pilosa*; 9, *O. greenii*; 10, *O. mucronata*; 11, *Neostaphia colusana*; 12, *Pappophorum pappiferum*; 13, *P. mucronulatum*; 14, *Cottea pappophoroides*; 15, *Enneapogon desvauxii*; 16, *Schmidia pappophoroides*. Note in Figs. 7-11 (Orcuttieae) that the embryos are very similar except that 7 and 8 have no epiblast. Note particularly the elongated solid coleoptilar tip. In Figs. 12-16 (Pappophoreae) the embryos are very similar in longitudinal section, but in transection 12 and 13 (subtribe Pappophorinae) have an embryonic leaf in which the margins meet but do not overlap, whereas in 14-16 (subtribe Cottinae) the embryonic leaves have overlapping margins. These figures are not drawn to the same scale.



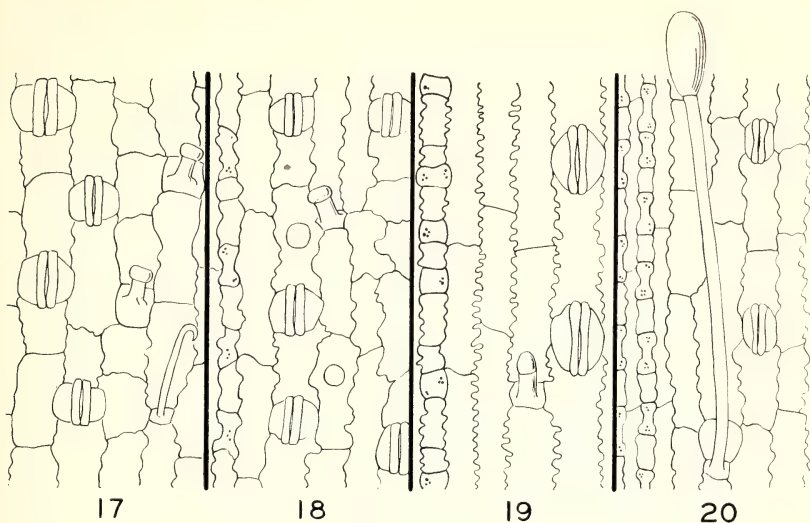
not pluricellular, but are clearly bicellular. Jacques-Félix (1962) likewise figures bicellular hairs of this type in *Enneapogon* and *Schmidtia* from Africa.

Tateoka et al (1959) discuss and figure these elongated bulbous-tipped bicellular hairs, which they state they found in *Enneapogon*, *Schmidtia*, and *Pappophorum elegans*. Stebbins and Crampton (1961) also report these distinctive hairs in the latter species, as well as in *Cottea* and *Enneapogon*. Actually, Tateoka et al, and also Stebbins and Crampton are the victims of bad taxonomy. *Pappophorum elegans* Nees is, in fact, a species of *Enneapogon*, and was transferred to that genus by Stapf in 1907! Stebbins and Crampton have also made a faulty observation, since they state (p. 143): "The present writers have determined that in *Cottea* the stalk itself is composed of two cells, so that the hair is actually tricellular rather than bicellular." We have examined the epidermis of *Cottea* and find the hairs to be clearly bicellular as reported by Caceres and Tateoka et al. The reports by Prat (1935), Caceres (1958), and Jacques-Félix (1962), that siliceous cells in *Cottea*, *Enneapogon*, and *Schmidtia* are dumbbell-shaped, have been confirmed by the present study.

In the work referred to above, Caceres examined the epidermis of 5 species of *Pappophorum*. In all he found that the bicellular hairs were short and of the usual eragrostoid type. The siliceous cells of the lower epidermis were found to be saddle- (or double-axe) shaped, although on the upper epidermis they are cross- or dumbbell-shaped. These observations have been verified in the present study (fig. 19). Other workers who have examined the epidermis of correctly identified *Pappophorum* species have reported these same characteristics. It is seen, therefore, that on the basis of epidermal characters, *Pappophorum*, is somewhat different from other members of the Pappophoreae.

A further distinction between *Pappophorum*, on the one hand, and *Cottea*, *Enneapogon*, and *Schmidtia* on the other, is revealed by a study of the embryo. In longisection these are almost identical and are much like those of other grasses of the chloridoid-eragrostoid alliance. A transsection through the coleoptile region of *Pappophorum*, however, shows a festucoid leaf—one in which the margins meet but do not overlap (figs. 12, 13), whilst in the others, this leaf is of the panicoid type, having distinctly overlapping margins (figs. 14–16).

In view of the differences found in both epidermis and embryo between *Pappophorum* and the other genera, it might seem appropriate to consider that they represent two distinct tribes. Although there is, indeed, some justification for such a treatment, in the writer's opinion these genera are so similar morphologically that they are better kept together. Such an alliance is not an unnatural one since all have a similar basic chromosome number and in other respects clearly have eragrostoid affinities. The one gross morphological character which appears to separate *Pappophorum* readily from the others is its 1-nerved glumes; in the others the glumes are several-nerved. Although these differences do not



FIGS. 17-20. Portion of the lower epidermis from a leaf,  $\times 225$ . 17, *Neostaffia colusana*; 18, *Orcuttia mucronata*; 19, *Pappophorum bicolor*; 20, *Cottea pappophoroides*. Note distinctive stomata and "mushroom-button" microhairs in *Neostaffia* and *Orcuttia* and the crozier hairs in the former. Also that *Pappophorum* has double-axe shaped siliceous cells and typical chloridoid microhairs, in contrast to *Cottea* in which the siliceous cells are dumbbell-shaped and the microhair has a slender elongated basal cell and a bulbous apical cell.

appear to be sufficient for tribal separation, subtribes seem clearly to be indicated.

### Tribe PAPPOPHOREAE Kunth, Rév. Gram. 1:82. 1829.

Subtribe PAPPOPHORINAE. *Pappophorum* Schreb. ex Vahl, Symbol. Bot. 3:10. 1794.

Subtribe **Cottinae** Reeder, subtribus nova. Gramina perennia vel rare annua; spiculis plurifloris, glumis et lemmatibus multinerviis, aliquot vel omnibus nervis lemmatum in aristas extendentibus; embryo cum formula  $P + P P$ ; epidermide foliorum cellulis siliceis halteriformis, pilis bicellulariis cum cella apicali glandulosa et plusminusve bulbosa, cella basali angusta, plerumque elongata.

Plants perennial or rarely annual; spikelets several-flowered, glumes and lemmas many-nerved, some or all of the nerves extending into awns; embryo with the formula  $P + P P$ ; leaf epidermis with dumbbell-shaped siliceous cells and bicellular hairs with a glandular, usually bulbous, apical cell and a slender, usually much elongated, basal cell.

Included genera: *Cottea* Kunth, Rév. Gram. 1:84. 1829; *Enneapogon* Desv. ex Beauv., Ess. Agrost. 81, pl. 16, fig. 11. 1812, Jour. de

Bot. 1:70. 1813; *Schmidtia* Steud. in J. A. Schmidt, Beitr. Fl. Capverdischen Ins. 144. 1852 (nom. conserv.); *Kaokochloa* deWinter, Bothalia 7:479. 1961.

This latter genus, which was recently described from Africa, clearly belongs to the subtribe Cottinae also. Through the kindness of Dr. deWinter we have recently received specimens and mature seeds of this grass for our studies. The leaf epidermis has dumbbell-shaped siliceous cells and the same type of elongated bicellular hairs which are characteristic of *Cottea*, *Enneapogon*, and *Schmidtia*. Moreover, the embryo, as in those genera, is of the formula  $P + P P$ , the embryonic leaf having overlapping margins. Dr. deWinter (in personal communication) states that he considers *Kaokochloa* to be a member of the Pappophoreae, closely allied to *Schmidtia*.

*Pommereulla* L.f., of India and Ceylon, is sometimes included in the Pappophoreae. Pilger (1954), however, treated it as a subtribe of the Festuceae, separating it from the Pappophoreae, which he considered a distinct tribe, but still assigned to the Festucoideae. Metcalfe (1960) reports chloridoid anatomy, and Bor (1960) has created for the genus a separate tribe, the Pommereulleae. Despite the anatomical similarity between *Pappophorum* and *Pommereulla*, in view of the very different gross morphology, the disposition by Bor seems fully justified. The tribe clearly belongs with the Eragrostoideae, however, and not with the Pooideae, as indicated by Bor.

Until recently it was thought that the elongate bulbous-tipped bicellular hair, shown here to be characteristic of the subtribe Cottinae, did not occur outside the Pappophoreae. Nicora (1962), however, has found hairs of a similar type in *Neeragrostis reptans* (Michx.) Nicora (*Eragrostis reptans* Michx.). Such unusual hairs immediately suggest a relationship between *Neeragrostis* and Cottinae, but in gross morphology they are very different. In the former the plants are dioecious annuals with 1-nerved glumes and 3-nerved awnless lemmas. Although future study may reveal some close affinity, the evidence now available does not appear to warrant assignment of *Neeragrostis* to Pappophoreae, subtribe Cottinae.

#### LIST OF SPECIES STUDIED AND SOURCES OF MATERIAL

The embryos were secured from mature seeds. These were embedded in paraffin, sectioned at 10 microns with a rotary microtome, and stained with saffranin and fast green. Leaf epidermis material was prepared by first boiling the leaf, then placing it on a slide and scraping away the tissue down to the epidermis. Portions of epidermal tissue thus obtained were stained in methylene blue and ruthenium red, dehydrated, and mounted in Permount.

*Crypsisniliaca* Fig. & DeNot. California, *Belluet & Henson*, Oct. 1944 (NY).

*Crypsis niliaca* Fig. & DeNot. California, *Belluet & Henson*, Oct. 1944 (NY).

*C. schoenoides* (L.) Lam. Pennsylvania, *Small*, Sept. 1897 (YU).

- Enneapogon desvauxii* Beauv. Mexico, Hidalgo, *Reeder & Reeder 1629* (YU); Durango, *Reeder & Reeder 2603* (YU).
- E. flavescens* (Lindl.) Burb. Australia, Queensland, *Blake 8054* (US).
- E. glumosus* (Hochst.) Marie & Weiller. West Africa, French Sudan, *Hagerup 441a* (US).
- Kaokochloa nigrirostris* deWinter. South West Africa, Kaokoveld, *deWinter & Leistner 5679A* (YU).
- Neostapfia colusana* (Davy) Davy. California, Solano Co., *Crampton 5421* (YU); *5406* (YU); Stanislaus Co., *Crampton 5026* (YU).
- Orcuttia californica* Vasey var. *inaequalis* (Hoover) Hoover. California, Merced Co., *Crampton 5433* (YU); *5040* (YU).
- O. californica* var. *viscida* Hoover. California, Sacramento Co., *Crampton 5125* (YU).
- O. greenei* Vasey. California, Butte Co., *Crampton 5069* (YU).
- O. mucronata* Crampton. California, Solano Co., *Crampton 5113* (YU); *5057* (YU).
- O. pilosa* Hoover. California, Stanislaus Co., *Crampton 5431* (YU).
- O. tenuis* Hitchc. California, Shasta Co., *Crampton 5078* (YU); *5079* (YU).
- Pappophorum bicolor* Fourn. Texas, *Reeder & Reeder 2899* (YU).
- P. mucronulatum* Nees. Arizona, *Gooding 124-47* (YU).
- P. pappiferum* (Lam.) Kuntze. Paraguay, Puerto Casado, *Hartley SH121* (US).
- Schmidtia pappophoroides* Steud. Africa, Rhodesia, *Hitchcock 24170* (US).

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## REVIEWS

*Flora of Missouri.* By JULIAN A. STEYERMARK. lxxxiv + 1725 pp., 390 plates (line drawings), 2409 distribution maps, 1 text figure. Iowa State University Press, Ames. 1963. \$18.50.

The appearance of this large, detailed flora (it weighs over five and one-half pounds) is a tribute to the author's persistence and industry. During the quarter century that it has been under way he has been living most of the time outside the state. Except at rare intervals it has been a project for evenings, weekends, and holidays.

In addition to keys, the volume presents the 2438 species now reported as occurring, or having once occurred, within the state of Missouri. Of these, 60 are ferns or fern allies, 6 are gymnosperms, and 2,372 are flowering plants. Between one-fourth and one-fifth of the species are introduced. These go all the way from species so well established that they might almost be taken for natives, to waifs collected in St. Louis freight yards by Viktor Muehlenbachs. (A minor but consistent error is the citation of this name without the terminal 's'.) The degree to which they are becoming established is usually indicated; attention is called to those few which are proving troublesome.

Whether we like it or not these introduced species are playing an ever increasing role in our vegetation. The completeness and precision of Steyermark's record will make it a baseline for future investigations of this basic biological problem.

Another of the author's special interests has been minor variations in flower color, pubescence, and growth habit; the flora lists 297 forms, many of them previously named by him. As basic data about variation, these are a valuable record, particularly when effort has been made to make it so complete.

In citing forms and varieties Steyermark follows the machinery set up by the International Code. If a form or variety is cited then the specific name is repeated as a pigeonhole for the specimens not otherwise catalogued at that level. This makes for a complicated text and takes up space. Steyermark reports it as a scheme easily dealt with editorially.

An introductory chapter gives expositions of the thinking behind his editorial decisions. It includes a chronological sketch of the principal Missouri collectors and the areas in which they were active. He estimates their total output as over 200,000 numbered collections.

A chapter on "Flora and Vegetation" has a summary of the basic physiography of the state followed by his delimitation of its plant regions: Southeastern Lowlands, Ozark, Prairie. He describes characteristic habitats in each with further details about salt licks, saline springs, upland sinkhole ponds and loess hills. He lists those species known from bordering states for which there is a sporting chance they might be found in Missouri.



There is a large detailed county map arranged for ready reference, an index of common and scientific names, a supplement of 17 additions while the book was in the press, and tables totaling genera, species, varieties, forms, and hybrids, family by family, with various summaries.

Line drawings are provided for all but a few species. These are from a variety of sources and are of uneven merit. For virtually all the species there is a map of distribution by counties. In addition to herbarium specimens these are based on careful field surveys. There is the scientific name recognized by the author and when this differs from commonly accepted ones, these synonyms are given. Flowering seasons are summarized by months from herbarium records. The range outside the state is indicated.

For many of the species there is further information about a variety of matters; details of the habitat; the uses made of certain plants by wild animals, pioneers, Indians and modern man; poisonous properties; plants causing hay fever and dermatitis. Those he has himself used for food are indicated and there is even an occasional recipe. For several aquatics he describes the morphological effects of changing water levels. For various species he has interesting comments about their behavior in the wild-flower garden he long maintained at his home in northern Illinois. — EDGAR ANDERSON, Missouri Botanical Garden, St. Louis.

*Families of Flowering Plants of Southern Africa.* By HERBERT PARKES RILEY. xviii + 269 pp. University of Kentucky Press, Lexington. 1963. \$14.00.

An unusual taxonomic publication has been prepared by Dr. Riley, Professor and Head of the Botany Department at the University of Kentucky. It is one of the first regional floras to contain rather extensive listings of chromosome numbers, many published here for the first time. Many of the chromosome counts were made by the author from collections of African plants, or from chromosome counts made during one year spent in South Africa on a Fulbright Fellowship.

The person unfamiliar with South African plants gains much insight into the floristics of that part of the world through the introductory chapter which includes 3 maps showing respectively the political, physiographic and vegetative features of the area. The first 7 photographs in the book show different South African plant associations. Two excellent photographs of cone bearing male and female plants of *Encephalartos kosiensis* are included as illustrations of one type of gymnosperm from the coastal subtropical forest near the Indian Ocean (on page 8, not 81, as indexed). The last 6 photographs in the book are almost superfluous, representing introduced plants around the settings of dwellings, including introduced plants such as *Bougainvillea*, *Carica papaya*, *Pinus*, and *Jacaranda*. The remainder of the 144 photographs are illustrations of plant families in Southern Africa, some in cultivation, but many in their native habitats. Unfortunately the photographs are not indexed at the back of the book and are only found within the text where specific genera are described in each family. No indication of the family is given by the photograph. If all plates illustrating one family had been listed just below the title of each family, or some similar means of relating the illustrations to families, the illustrations would prove more useful to persons unfamiliar with African families. Since all the photographs are in color, arranged 6 to a page, generally with high quality photography and color reproduction, the color photographs alone are worth the price of the book.

Most American botanists are familiar with the Englerian system of classification, and some have become acquainted with the Bentham and Hooker system, the latter more widely used by the British. Dr. Riley has used a modified system, based on John Hutchinson's herbaceae-lignosae system. Although Hutchinson's system gives insight to some relationships that other systems have ignored with its much-branched trees from two sources, it is not well suited to a linear sequence. It is difficult to

see that new understanding of relationships is gained, for instance, by the following sequence of families (pp. 38-44): Escalloniaceae, Cornaceae, Araliaceae, Hamamelidaceae, Myrothamnaceae, Buxaceae, Bruniaceae, and Salicaceae!

It is unfortunate that a book of plant families is not indexed for the scientific names of all the families. The extensive index is 15 pages, 5 columns wide, but contains only generic or for the most part common and Afrikaans names of plant families. Thus Ginger and Ginger family are listed, but not Zingiberaceae. Barberry family is listed, but not Berberidaceae. Where does one look for Hamamelidaceae (not indexed), if one does not know the common name?

Much useful information is contained about genera, such as their uses by natives and Europeans living there, and the ornamental value of the plants. The book uses generic concepts very close to those of Phillips in his *Genera of South African Plants*. A check shows that the families are very closely matched, and Riley has added at least one family: Taccaceae.—ROBERT J. RODIN, California State Polytechnic College, San Luis Obispo.

*Vascular Plants of the Pacific Northwest*. By C. LEO HITCHCOCK, ARTHUR CRONQUIST, MARION OWNBey, and J. W. THOMPSON. Part 2, vi + 597 pp., illustrated. University of Washington Press. 1964. \$15.00.

Publication of this second part of the series marks the completion of the treatment of the dicotyledons. My earlier comments on the work (Madroño 15:74-76; 17:90-91) are still applicable to the present part, which covers Salicaceae through Crassulaceae. Preceding the main text are two keys to the families of dicotyledonous plants in the region covered. One is a synoptical key intended to aid in an understanding of Cronquist's phylogenetic arrangement of families (which is not followed in this work) and the other is an artificial key which almost everyone will use for identifying families. All families in this part but Salicaceae were treated by Hitchcock. The same high standards of previous contributions are maintained. The only new taxa described are several varieties but numerous changes in taxonomic rank are made. In spite of ever-increasing inflation, the University Press has managed to keep the price per page of the series remarkably stable.—ROBERT ORNDUFF, Department of Botany, University of California, Berkeley.

*Generic Names of Orchids*. By RICHARD EVANS SCHULTES and ARTHUR STANLEY PEASE. xvi + 331 pp. Academic Press, New York, London. 1963. \$12.00.

This work represents a valuable addition to the literature relating to the Orchidaceae. It will be useful to anyone who is interested in this vast family, whether professional or amateur. The book is beautifully printed, ornamented by numerous illustrations and vignettes, and will be an embellishment to any library.

The production is exactly what it claims to be—a dictionary that explains the etymological history of the 1250 generic names of Orchidaceae and the morphological or other characteristics of each plant that led to the choice of the generic name. Also included are the original Greek or Latin components of the names, along with the geographic distribution and tribal or subtribal classification of the genus shown together with the place of first publication of the epithet. A lengthy introduction reviews the Orchid Family taxonomically, historically, and ethnobotanically, and explains briefly the importance of and rules governing nomenclature.

Since the authors state that it was not their purpose to make this dictionary in any way a taxonomic treatment, they have precluded any criticism that might be forthcoming due to this deletion.

Both authors are outstanding scholars in their respective fields at Harvard University: Schultes in economic and systematic botany, and Pease, an emeritus

professor of Latin who also excels in botany as an avocation. These two formed a superior association to produce this volume. Fortunately, to supplement their manuscript, the authors were able to make use of numerous illustrations that have accrued through the years to the Oakes Ames Orchid Herbarium of Harvard, some of which have previously been used to delineate the various orchid floras that have been produced in the Ames Herbarium.

The scholarship evidenced by this work makes it a very worthwhile contribution, and it should be available to all who are interested in orchids. A leisurely perusal through this attractive book will be an enlightening experience for anyone.—DONOVAN S. CORRELL, Texas Research Foundation, Renner.

## NOTES AND NEWS

**TRANSLOCATION HETEROZYGOSITY IN *CROTON CALIFORNICUS*.**—A morphologically relatively uniform population of *Croton californicus* var. *tenuis* (Wats.) Ferg. from Point Dume, Los Angeles Co., California, was examined cytologically from buds of male plants growing on the sand dunes near the edge of the bluff or in the rock crevices just below (LA 33482). Buds were fixed in Carnoy solution and examined after squashing in acetocarmine.

Meiosis of seven plants could be examined and gave the following results: one plant consistently formed 14 pairs and was apparently structurally homozygous; five plants regularly showed 12 pairs and a ring of 4 chromosomes, indicating structural heterozygosity for one reciprocal translocation; one plant showed 10 pairs, a ring of 4, and a chain of 4 chromosomes, indicating that it was heterozygous for two translocations.

The chromosome number ( $2n = 28$ ) is new for the genus *Croton*. Previous counts, for *C. glandulosa*, *C. monanthogynis*, and *C. palmeri* by Perry (see Darlington and Wylie, Chromosome Atlas of Flowering Plants, 1956), have all been  $2n = 16$ . The present count suggests, therefore, a second basic number of 7.

Of special interest, however, is the high frequency of translocation heterozygotes. Although the present sample is small, it suggests that translocation heterozygosity may be an integral part of the adaptive genetic system of the population. It is also interesting to note that pollen fertility is apparently extremely variable. Some individuals had as low as 30 percent visibly good pollen when stained with cotton blue in lactophenol, whereas others had as high as 96 percent stainable pollen. The variation did not appear, however, to be directly correlated with structural heterozygosity. Further study of the cytology and genecology of this polytypic species should be rewarding. Such a study has been initiated by S. Smith-White and Albert W. Johnson.

These observations were made in the Botany Department of the University of California, Los Angeles, during my tenure as a Rockefeller Foundation Fellow. I am indebted to Harlan Lewis and Kunyama Mathew for their helpful advice and assistance.—JERZY SZWEYKOWSKI, Adam Mickiewicz Univ., Poznan, Poland.

**UNITED STATES NATIONAL HERBARIUM.**—During the month of June 1965, the Department of Botany of the U.S. National Museum, which includes the U.S. National Herbarium, will be moving from its present quarters in the Smithsonian Institution Building into the new west wing of the Museum of Natural History Building. The new space will provide the department with two complete floors for specimen storage, laboratories, libraries, offices, rooms for visiting botanists, and herbarium maintenance facilities.

It is estimated that preparation for the move will occupy a 3-month period, and an equivalent amount of time will be needed to arrange our property and resume activities after the move has taken place. Regretfully, it will be necessary for the best interests of the Herbarium and our correspondents throughout the world to request a moratorium on the receipt and shipment of herbarium specimens during this period.



We ask that between April 1, 1965 and October 31, 1965, no specimens be sent to us, nor that we be requested to ship specimens on loan. Specimens received during this period will be retained for processing until after October 31, 1965; requests for specimens also will be held for action until after this rate.—WILLIAM L. STERN.

CROCIDIUM IN SAN LUIS OBISPO CO., CALIFORNIA.—*Crocidium multicaule* Hook. (Compositae-Senecionaceae), an annual herb of uncertain affinities which is the only species of its genus, is reported to range from Vancouver Island southward to the Mount Hamilton Range of central California. Now it can be reported some 130 mi to the south, on the basis of the following collections: damp sandy soil on north slopes of narrow canyons above semi-permanent streams, the Bear Trap, foot of Castle Mountain, on the headwaters of San Juan Creek, San Luis Obispo Co., *Hardham 11001* (DS), Feb. 8, 1964; *Hardham 11007* (Cas, DS, OSC, RSA, US), March 8, 1964. Since Ornduff (Leafl. West. Bot. 9:84. 1960) recently pointed out that forms of this species with epappose ray florets occur throughout its range, with the possible exception of the populations in the central Sierra Nevada foothills of California, we asked Mrs. Hardham to obtain a sample from her isolated population on which to score this character. Her no. 11007 thus consisted of 214 individuals obtained at intervals along a transect of about a mile in length. All 214 of these individuals, as well as all 13 in no. 11001, had pappose ray florets. Whether this is the result of the origin of this colony from a few original plants with pappose ray flowers, or the genes controlling this characteristic are linked with others physiologically favorable for survival at this southern station, cannot be determined at present.—PETER H. RAVEN and THOMAS R. MERTENS, Division of Systematic Biology, Stanford University.

A REED COLLEGE HERBARIUM.—Plant taxonomists working on the flora of the Pacific Northwest are generally unaware of the existence of a small herbarium housed in the Department of Biology at Reed College, Portland, Oregon. The purpose of this note is to describe its contents and to bring it to the attention of interested botanists. The herbarium contains an extensive collection of vascular plants of Multnomah Co. made by Richard van Dersal in the late 1920's; plants of the Mount Hood region collected by Kate C. Rogers in 1938; specimens of the native, weedy, and cultivated plants of the college campus collected by Una V. Davies in 1937–1938; and a number of species from Ocracoke Island, North Carolina, deposited by Katherine Rondthaler in 1951. There are also small collections of Oregon mosses gathered by Carra Horsfall and by Margery Washburn, and miscellaneous vascular plants collected in various parts of Oregon by Donald B. Lawrence. The majority of these collections was made in connection with the preparation of baccalaureate theses, none of which has been published. In addition to these collections by former students there are numerous plants collected in Oregon and Washington by two pioneer northwestern botanists—Thomas Howell and William Cusick. Finally, there are several sheets bearing collections made elsewhere in the United States by such botanists as Canby, Chickering, Hasse, Hapeman, Hyams, Kellerman, and Vasey. This herbarium is, therefore, of moderate historical interest. Because it houses a number of unicates from northwestern Oregon it should certainly be consulted by botanists working on the floristics of this portion of the state.—ROBERT ORNDUFF, Department of Botany, University of California, Berkeley.

Salisbury



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ALLOLEPIS: A NEW SEGREGATE OF DISTICHLIS  
(GRAMINEAE)

THOMAS R. SODERSTROM AND HENRY F. DECKER

In a recent study to establish the relationships of the grass *Reederochloa* (Soderstrom and Decker, 1964), the authors studied the morphology and anatomy of species of the similarly dioecious genus *Distichlis*. Attention was drawn in particular to *D. texana*, a rather robust species which has been collected only rarely from the Big Bend country of Texas to El Paso and south into Coahuila, Chihuahua, and Durango, Mexico. The species was first described by Vasey (in Coulter, 1890) as *Poa texana*, based on a collection made by G. C. Nealley in 1887, apparently in Presidio Co., Texas. In the description Vasey states that all of the specimens are male and questions whether or not the species might be dioecious. Later (1893) when both male and female plants were available to him he redescribed it as *Sieglingia wrightii*, pointing out his earlier misinterpretation. The name *Sieglingia* is now valid only for the single species, *S. decumbens*. What Vasey evidently had in mind when he used the name was a group of species which now are included in the genera *Tridens* and *Erioneuron*, in which no dioecious members are found. Nine years after being first described, the species found its way into yet another genus, this time *Distichlis*, to which it was transferred by Scribner (1899). Scribner felt it belonged in *Distichlis* because of "the dioecious habit, the character of the inflorescence, the rigid subcoriaceous glumes, long-exserted styles protruding from the apex of the floret, and grains enclosed in the coriaceous base of the palea." This disposition was accepted by Hitchcock in the first edition of *Manual of the Grasses of the United States* and in the 1950 edition revised by Agnes Chase.

Since the time of Scribner and Hitchcock, characters of leaf anatomy have come to play an increasingly important role in elucidating the true relationships of grasses. Studies of *Reederochloa*, for example, showed that the leaves of that genus possess peculiar bicellular microhairs in which the enlarged bases are actually sunken in the epidermis. Such hairs are found also in *Monanthochloë* and, with the exception of *D. texana*, in all species of *Distichlis*. The genera with this type of microhair share many other anatomical as well as morphological characters, such as the dioecious habit and coriaceous many-nerved lemmas and glumes, which unite them into a close, natural association. *Distichlis texana* (for the genus and indeed for this whole alliance) is striking because its bicellular microhairs are not sunken but are of the normal eragrostoid type, similar to those found in *Eragrostis*, *Muhlenbergia*, *Sporobolus*, etc. This dissimilarity of bicellular microhairs prompted a more thorough look at *D. texana* and the other members of the genus. Our studies revealed that this species differs remarkably in fundamental anatomical and morpho-

logical characters and has indeed been misplaced even in *Distichlis*. Now, after 65 years in the latter genus, we choose to remove it and recognize it separately as a new genus, *Allolepis*, the fourth generic name to be associated with this interesting grass.

**Allolepis** Soderstrom & Decker, gen. nov. Perennis dioica stolonifera; culmi ascendentes vel decumbentes, vaginae forte costatae, glabrae; ligula brevis, ciliata; rami paniculae appressi vel ascendentes, plerumque ad basin floriferi. Planta masculina: Spiculae ovato-lanceolatae vel lineares, stramineae, illustres; glumae ovatae, hyalinae, glabrae; gluma prima 1-nervia, quam secunda paulo brevior; gluma secunda 1(–3)-nervia; lemmata forte 3-nervia, glabra, illustria; palea lemma aequans vel quam lemma paulo longior, linearis, glabra; antherae 3, flavae. Planta feminea: Spiculae ovato-lanceolatae, teretes vel paulo compressae, stramineae; glumae ovatae, coriaceae, glabrae, marginibus membranaceis; gluma prima quam secunda paulo brevior et angustior, forte 1-nervia (interdum cum ampliis nerviis indistinctis); gluma secunda 3-nervia (interdum cum ampliis nerviis indistinctis); lemmata forte 3-nervia (interdum cum ampliis nerviis indistinctis), glabra, ovata, coriacea, marginibus scariis; palea quam lemma paulo brevior, a latere visa supra versus angusta et linearis, basin versus curvata, glabra; lodiculae 2, cuneatae.

Type species: **Allolepis texana** (Vasey) Soderstrom & Decker, comb. nov. *Poa texana* Vasey, Contr. U.S. Natl. Herb. 1:60. 1890. *Sieglingia wrightii* Vasey, Contr. U.S. Natl. Herb. 1:269. 1893. *Distichlis texana* (Vasey) Scribn., U.S. Dept. Agri. Div. Agrost. Cir. 16:2. 1899, based on *Poa texana* Vasey.

The following description of *A. texana* is intended to supplement previous descriptions of this taxon which have been scanty and based on fewer specimens than those available at this date: Perennial, dioecious, stoloniferous, the stolons glabrous, strongly ribbed, 1–4 mm broad, to 25 cm long; culms loosely ascending or spreading as stolons, 10–70 (25–65) cm long (from point of rooting to base of inflorescence), glabrous; nodes 3-several, glabrous; lower sheaths shorter than the internodes, strongly ribbed, glabrous; blades flat when dry, sometimes involute toward the tip, to 30 or more cm long, 2.5–6 (4–5) mm wide, glabrous above and below, becoming scaberulous toward the tip, the edges scabrous; ligule short-ciliate from an inconspicuous membranous base, 0.5–1.4 (0.5–1) mm long; inflorescence a panicle, 3–23 (10–17) cm long, 1–6 (1–3) cm wide, consisting of stiffly appressed or ascending branches 3–6 cm long, usually floriferous to the base, the panicles containing as many as 70 spikelets; lodicules 2, cuneate in outline. Male plant: Spikelets ovate-lanceolate to linear, stramineous, lustrous, 9–23 (10–15) mm long, 3–8 (3–6) mm wide, up to 20 florets per spikelet, apparently not disarticulating; glumes broadly ovate, hyaline, glabrous, the midnerve scabrous; first glume a little shorter than the second, ca. 4–5 mm long, 1-nerved; second glume ca. 1 mm longer than the first,



1(-3)-nerved; lemmas of lower florets 5-5.5 mm long, strongly 3-nerved, glabrous, lustrous; palea equal to or a little longer than the lemma, linear, glabrous, the keels minutely ciliolate; anthers 3, yellow, 3-3.5 mm long. Female plant: Spikelets ovate-lanceolate, terete or only slightly compressed, stramineous, 1-2 cm long, 2.5-3.5(3) mm wide, with up to 8 or 9 closely imbricate florets per spikelet, apparently not disarticulating; glumes broadly ovate, coriaceous with broad scarious margins, glabrous, the midnerve scabrous; first glume a little shorter and narrower than the second, ca. 7-9 mm long, strongly 1-nerved (up to 4 or 5 additional faint nerves may be present); second glume 3-nerved, with an additional 1 or 2 pairs of faint nerves sometimes present; lemmas of the lower florets 7.5-10 mm long, strongly 3-nerved, glabrous, midnerve scabrous above, broadly ovate, coriaceous with irregular scarious margins; palea a little shorter than the lemma, narrow above and strongly bowed out below, the margins overlapping, glabrous, the keels ciliolate.

Specimens examined. UNITED STATES, TEXAS. Without precise locality (Presidio Co. ?): *Nealley s.n.*, in 1887 (Isotype, US: ♂ plants, basis of *Poa texana* Vasey). Brewster Co.: Castalon, *Silveus* 648 (TAES, TEX, US). Jeff Davis Co.: *Brown* 53-240 (TEX: cultivated in Univ. Texas grass garden); *Brown s.n.*, 25 July 1949 (TEX); *Brown s.n.*, 1 Aug. 1950 (TEX: grown in Univ. Texas grass garden, cytological voucher); *Hinckley* 4571 (US); *Hinckley & Hinckley* 316 (US); Limpia Canyon, *Nealley s.n.*, in 1892 (US); *Warnock* 7942 (LL, SMU, TEX); *Warnock* 8039 (LL, SMU); *Warnock* 10187 (LL, SMU); Valley of the Limpio, *Wright* 2038 (US: ♀ plant, basis of *Sieglingia wrightii* Vasey). Presidio Co.: *Nealley* 136 (TAES); *Nealley* 137 (NY, US); near Presidio, *Nealley s.n.*, in 1892 (US); *Silveus* 737 (US); *Warnock* 158 (TEX, US).

MEXICO. Chihuahua: 5 km west of Cd. Camargo, *Harvey* 1412 (US). Coahuila: Saltillo, *Palmer* 507 (NY, TAES, US). Durango: Torreón, *Hitchcock* 7541 (US).

A photograph of a single plant of *Allolepis* clearly showing its strong stoloniferous habit is given by Silveus (1933). There is also an excellent illustration of the habit and of the male and female spikelets (Scribner, 1901), and a sketch of the female panicle and spikelet (Hitchcock, 1950).

*Allolepis* can at once be distinguished from *Distichlis* by the absence of scaly rhizomes and presence of long, thick stolons. *Distichlis* rarely produces narrow stolons but, when found, they are in addition to the scaly rhizomes which are so characteristic of the genus. Beetle (1943) has even recognized as a variety of *D. spicata* some California plants with stolons, *D. spicata* (L.) Greene var. *stolonifera* Beetle, but these are apparently produced only under certain conditions and do not seem to be correlated to any degree with other characters. The length of the stolons in *Allolepis* is hardly apparent on herbarium specimens which represent only segments of the whole. Silveus (1933) states that they are about 10 ft long and Barton Warnock (pers. comm.) of Sul Ross State College, Alpine, Texas, has observed in the field that some of them are easily 50 ft long. The blades of *Distichlis* are narrow, involute, pungent and arranged on the culm in an obvious distichous manner, hence the generic name. In contrast, those of *Allolepis* are flat, longer and broader, and not arranged in such a distinct distichous fashion.

The male and female spikelets of *Distichlis* are about equal in size within the same species: each is composed of several florets, the lemmas of which are coriaceous and many-nerved. In *Allolepis*, the female spikelets are about twice as large as the male spikelets and the texture and nerves of the lemmas in each are distinct. Lemmas of the male spikelets are thin in texture and strongly 3-nerved whereas those of the female spikelets are coriaceous and 3-nerved but occasionally with an additional pair of faint nerves. The 3-nerved condition of the lemmas is quite unlike that of the *Distichlis-Monanthochloë-Jouvea-Reederochloa* alliance in which the lemmas of both sexes are consistently coriaceous and many-nerved. The palea offers a further distinction between the two genera, for the keels of the palea in *Distichlis* are winged but in *Allolepis* they are not.

The dissimilarity of lemmas between the sexes of *Allolepis* has suggested its new name, a synthesis of the Greek words *allo* (different) and *lepis* (scale, or lemma).

The most prominent difference in the leaf epidermis between *Allolepis* and *Distichlis* is the microhair—normal eragrostoid in the former (fig. 1A), bulbous-based and sunken in the latter (fig. 1B). The shape of the siliceous cells is irregular ("potatolike") in *Distichlis* (fig. 1D), predominantly dumbbell-shaped in *Allolepis* (fig. 1C). The epidermal surface of *Distichlis* is rough and irregular due to the presence of many papillae (fig. 1B) while that of *Allolepis* has few or no papillae and hence is relatively smooth. A few minor differences are also encountered in the leaf cross section. Arm cells (fig. 1A) are conspicuous in each bundle of an *Allolepis* leaf but not obvious, when present, in *Distichlis*. The bulliform cells of *Allolepis* (fig. 1A) are relatively large in tall girders and the outer bundle sheath is elongate in outline and complete on most of the bundles. The bulliform cells of *Distichlis* (fig. 1B) are relatively small and in short girders and the outer bundle sheath is generally round in outline and complete only on the smaller bundles.

From published chromosome reports, no cytological distinction can be made between the two genera. Brown (1951) has listed a count of  $2n=40$  for *Distichlis texana* (*Allolepis*). Similar counts have also been given for *D. spicata* from California material (Stebbins & Love, 1941) and Argentine material (Rahn, 1960), and for *D. stricta* from Canadian material (Bowden, 1960) and California material (Stebbins & Love, 1941). The basic number of  $x=10$  indicates these genera do not belong in the traditional tribe Festuceae but rather to the eragrostoid complex, as substantiated by the leaf anatomy and other studies (Soderstrom and Decker, 1964).

*Distichlis*, *Reederochloa*, *Monanthochloë*, and *Jouvea* are plants of saline habitats. The latter two are strictly littoral or maritime; of the former two, *Reederochloa* occurs in alkaline inland flats, and *Distichlis* occurs both along the coasts and in saline areas of the interior. Information regarding the habitat of *Allolepis* has been difficult to obtain, especially since so few botanists have collected it. To our knowledge the only



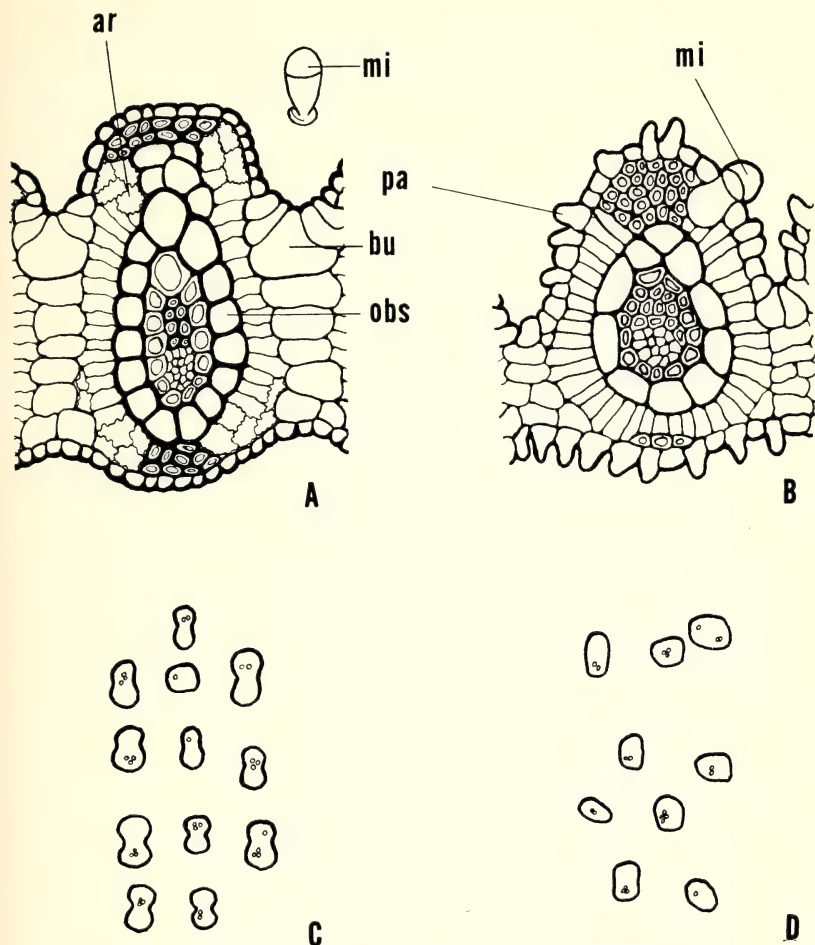


FIG. 1. A, B, Transverse sections of grass leaves; C, D, portions of the bands of siliceous cells over the costal regions on the epidermis of grass leaves; A, C, *Allolepis texana* (Silveus 648); B, D, *Distichlis spicata* (Reeder & Reeder 3074). The illustrations were done with the aid of a microprojector and are at various magnifications: ar, arm cell; bu, bulliform cell; mi, bicellular microhair; obs, outer bundle sheath; pa, papilla.

living botanists in Texas who have collected the genus are Barton Warnock and W. V. Brown. Warnock remarks (pers. comm.)<sup>1</sup> that he found it growing in igneous sandy soil in a broad flat among *Hymenoclea monogyra*, and also in silty soil at the mouth of Cibolo Creek between the town

<sup>1</sup> We wish to acknowledge the information supplied to us by Barton H. Warnock.

of Presidio and the international bridge where it was rather abundant. Silveus (1933) gives cultivated and waste meadowlands or sand flats as the habitat. It has even been cultured successfully in ordinary loam in the University of Texas grass garden. Such information, plus the scanty data available from herbarium labels, does not indicate that *Allolepis* is a plant of alkaline areas. If this is the case, it presents us with yet another major feature to distinguish it from *Distichlis* and related genera.

Voucher specimens. Leaf cross sections and epidermis of the following specimens were examined in this study. A taxonomic revision of *Distichlis* is much needed and such a study would probably reduce the number of valid species; nevertheless the material which we examined does at least represent the genus as it occurs in North and South America.

*Allolepis texana* (Vasey) Soderstrom & Decker. UNITED STATES. New Mexico (or western Texas): Wright 2038, ♂ (US). Texas: Nealley, in 1889, ♂ (US); Nealley, in 1892, ♀ (US); Castalon, *Silveus* 648, ♀ (US). MEXICO. Coahuila: Saltillo, Palmer 507, in 1898, ♀ (US).

*Distichlis hirta* Phil. CHILE. Batuco, Philippi 377, ♀ (US).

*D. humilis* Phil. PERU. Chuquibambillo, Hitchcock 22450, ♀ (US).

*D. marginata* Phil. CHILE. Atacama, Werdermann 997, ♀ (US).

*D. palmeri* (Vasey) Fassett ex I. M. Johnston. MEXICO. Sonora, Bacigalupi 2873, ♂ (US).

*D. scoparia* (Kunth) Arech. ARGENTINA. Neuquen, Senn 4329, ♀ (US).

*D. spicata* (L.) Greene. UNITED STATES. Connecticut: Lighthouse Pt., Reeder & Reeder 2756 (YU). Massachusetts: Cape Cod, Reeder & Reeder 252, ♂ & ♀ (YU). MEXICO. Michoacan, Reeder & Reeder 3074, ♂ & ♀ (YU).

*D. stricta* (Torr.) Rydb. UNITED STATES. Utah: Reeder & Reeder 1858, ♂ & ♀ (YU).

*D. thalassica* (H.B.K.) Desv. ARGENTINA. Mendoza, Bartlett 19530, ♂ (US).

*D. viridis* Phil. CHILE. Atacama, Werdermann 431, ♂ (US)

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## NATURAL HYBRIDIZATION BETWEEN CUCURBITA DIGITATA AND C. PALMATA

W. P. BEMIS AND THOMAS W. WHITAKER

*Cucurbita digitata* Gray and *C. palmata* Wats. are xerophytic, perennial species indigenous to the desert regions of southwestern United States and northwestern Mexico.<sup>1</sup> According to Bailey (1943) *C. digitata* is found in New Mexico, Arizona, sparingly in southeastern southern California (eastern Riverside County) and in Sonora, Mexico. It is doubtful that *C. digitata* is indigenous west of the Colorado River. In California it is found in limited roadside areas, suggesting that it was probably introduced by camper-tourists. *Cucurbita palmata* is found in southern California from the Mohave Desert southwards in interior valleys and at low elevations. It also occurs in western Arizona and northern Baja California, Mexico. In the area adjacent to the Arizona-California border and directly east of the Colorado River the species are sympatric.

Each species has 20 pairs of chromosomes (McKay, 1931). They also have similar growth patterns. The root systems have large fleshy storage roots which enable the plants to survive prolonged periods of high temperatures and extremely arid conditions. Vine growth is rapid under favorable conditions of moisture and temperature. Adventitious roots are produced at intervals on the nodes of the runners, and under favorable moisture conditions these roots are able to develop into tuberous roots which when separated from the mother vine will establish another plant. This asexual method of propagation produces a clone with the individual plants grouped in colonies. *Cucurbita digitata* and *C. palmata* are prolific producers of fruit and seed. The fruit is a relatively hard-shelled, round pepo, two to three inches in diameter, and contains from 200 to 600 seeds. Reproduction by seed, however, is probably limited because of low seed and seedling survival in the environments to which these species are adapted.

<sup>1</sup> We wish to acknowledge with thanks the assistance of F. D. Cole, University of Arizona, and Paul D. Hurd, Jr., University of California, Berkeley, for directing our attention to localities where hybrids were likely to occur. Dr. Hurd and Dr. Edgar Anderson have read and made suggestions for improvement of the manuscript.

## METHODS AND RESULTS

The most conspicuous morphological difference between the two species is leaf shape. The leaf of *C. digitata* has five lanceolate lobes with sinuses developed to the base of the leaf veins. The leaf of *C. palmata* has five palmate lobes with sinuses developed to approximately one-third the length of the leaf veins. The first four to six seedling leaves of both species are similar to *C. palmata*.

Since leaf shape is the most striking morphological difference between these species a method of measurement was developed to describe the leaves numerically. The measurement that was found to reflect the leaf differences was the ratio of the length to the width of the central palmate or lanceolate lobe and the two adjacent lobes. The length of the lobes was measured from the petiole attachment to the tip of the leaf blade. The widths of the lobes were measured at their widest point not including appendages which were present on some leaves. The widest point on the lobes of *C. palmata* leaves was at the base of the sinuses.

Figure 1 shows three diagrammatic *Cucurbita* leaves superimposed. The solid leaf represents *C. digitata* and has a length to width ratio of ten. The open leaf represents *C. palmata*, with a length to width ratio of two. The shaded leaf is intermediate between *C. digitata* and *C. palmata* with a length to width ratio of five and represents an  $F_1$  hybrid between the two species.

GREENHOUSE OBSERVATIONS. As a part of a general study of the genus *Cucurbita*, reciprocal crosses between *C. digitata* and *C. palmata* were made. The  $F_1$  and  $F_2$  generations were fertile, indicating these species are cross compatible.

Plants from self-pollinated seed of two *C. digitata* lines and one *C. palmata* line, along with the reciprocal  $F_1$  hybrids were grown in the greenhouse at the University of Arizona in the fall of 1963. The *C. digitata* lines originated from fleshy roots collected 5 miles and 22 miles N of Tucson, Arizona. The *C. palmata* line came from a fleshy root collected in the Yuma Valley, Arizona, adjacent to the Colorado River and 5 miles N of the Mexican border. Leaf ratio measurements for these seven plants are given in Table 1. Leaf ratios for the two *C. digitata* lines were  $9.42 \pm 1.66$  and  $8.34 \pm .72$  respectively, while for *C. palmata* the ratio was  $2.28 \pm .27$ . For the  $F_1$  hybrids of *C. digitata* ♀ x *C. palmata* ♂ the leaf ratios were  $4.62 \pm .39$  and  $4.89 \pm .39$ ; for the reciprocal cross the ratios were  $3.87 \pm .79$  and  $3.65 \pm .73$  (fig. 2). It is evident that the  $F_1$  hybrids are intermediate between the parent species. Data from the hybrids suggest a possible cytoplasmic effect on leaf ratios as they tend to show an effect of the female parent. More information on this question is necessary before a statement can be made. The point is that both kinds of hybrids do have intermediate leaf ratios.

FIELD OBSERVATIONS. The range of *C. digitata* and *C. palmata* overlap in the vicinity of the Arizona-California border roughly parallel to the Colorado River from near the vicinity of Davis Dam in southern



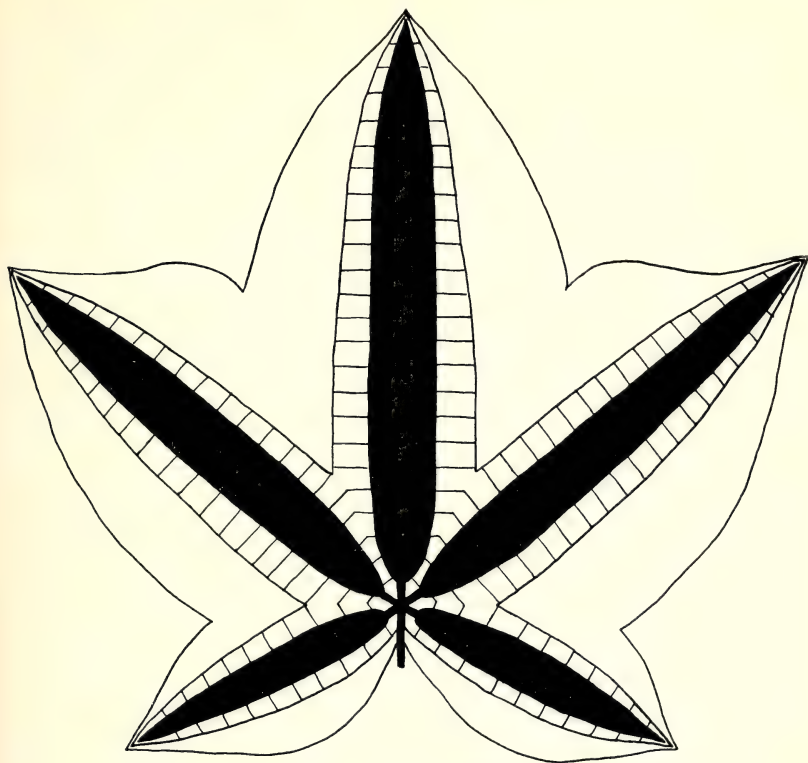


FIG. 1. Diagrammatic sketch representing a leaf of *C. digitata* (solid), *C. palmata* (open), and an intermediate (shaded).

Nevada, on the north to San Luis, Sonora, Mexico, on the south. In this general area one might expect natural hybridization between the two species to occur. Our attention was directed to some plants which appeared to be suspiciously like hybrids in the area north of Dateland, Arizona, by F. D. Cole and to the area between Quartzite, Arizona, and Yuma, Arizona paralleling Arizona Highway 95 by P. D. Hurd, Jr. Collections were made in the above two areas, and in a third area where Highway 95 crosses the Gila River, about 12 miles NW of Yuma and 6 miles E of the Colorado River. At each location herbarium specimens (ARIZ) were collected and leaf ratios were obtained.

Dateland locality. This locality is in the bed of the Gila River north of Dateland, Arizona. It is approximately 70 miles E of the Colorado River (Arizona-California border). The Gila River at this point forms a flood plain about two miles wide. The soil of the plain is a silty loam and it supports a dense growth of mesquite. The samples were taken from the south edge of this flood plain on Nov. 21, 1963. The soil of the flood plain had at one time been disturbed by heavy equipment operating at

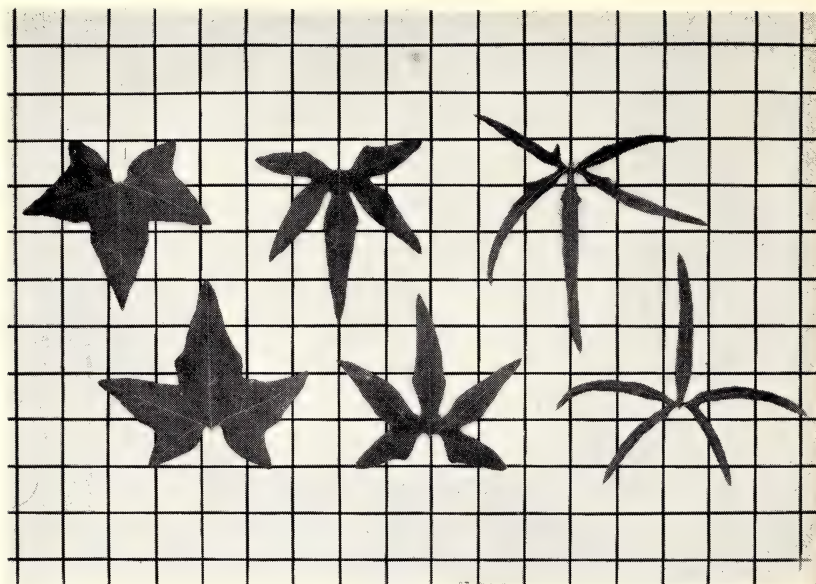


FIG. 2. Two representative leaves of *C. palmata* (left); F<sub>1</sub> (*C. palmata* × *C. digitata*) center; and *C. digitata* (right). Hybrids were produced from controlled pollinations.

a nearby sand and gravel quarry. The action of this equipment may have created favorable conditions for seed germination and seedling establishment of *Cucurbita* seed produced locally or from fruit transported down the Gila River during periods of flooding.

A particularly dense population of *Cucurbita* occupied an area approximately  $90 \times 150$  feet (fig. 3). From this area fourteen individual colonies were sampled. The leaf ratio data are given in Table 1 under "Dateland." Two plants from this area had leaf ratios indicative of "pure" *C. digitata*, and one plant was identified as *C. palmata* based on leaf ratio data. The remaining eleven plants had intermediate leaf ratios varying from  $5.60 \pm .72$  to  $2.97 \pm .38$  (fig. 4). The range in leaf ratios of intermediates suggests that they include segregates beyond the F<sub>1</sub> generation or perhaps backcrosses, or if they are representative of F<sub>1</sub> hybrids, that the parental species were not homozygous for factors controlling leaf shape. Plants with intermediate leaf ratios are undoubtedly the result of natural interspecific hybridization.

Yuma locality. A sample was taken where U.S. Highway 95 crosses the Gila River. This area is approximately 6 miles E of the Colorado River and 64 miles down river from the Dateland sampling area. The *Cucurbita* at this location were not particularly dense and only seven colonies were sampled on Dec. 19, 1963, in approximately a quarter mile length of the Gila River. Leaf ratio data for the seven plants from this area are given in Table 1 under "Yuma."



FIG. 3. Field photograph from Dateland, Arizona, showing runners from plants with digitata-like and palmata-like colonies intertwined. The pole is marked in dms.

Three of the plants had leaf ratios indicative of *C. palmata*, a fourth was like *C. palmata* but showed some indication of *C. digitata* contamination since it had a leaf ratio of  $2.85 \pm .27$ . Two plants were intermediate, and one plant was principally *C. digitata* but showed some evidence of *C. palmata* contamination with a leaf ratio of  $7.14 \pm .87$ . These limited data suggest that the dominant species in this area is *C. palmata* and that fruit and seed of *C. digitata* segregates were probably transported down the Gila River during periods of flooding.

Five locations on Highway 95. Eighteen colonies were sampled on Dec. 3, 1963, at 5 locations extending from 18 to 55 miles S of Quartzite, Arizona, on Highway 95. The colonies were located either in the stream bed or along the banks of dry washes that drain westward into the Colorado River. Abundant late summer and fall rains had produced excellent vegetative growth, but flowers and fruits were absent from most colonies.

Of the 18 colonies sampled, one appeared to be "pure" *C. palmata*, and 5 were *C. digitata* or *digitata*-like (Table 1). The remainder were inter-



TABLE 1. LEAF LENGTH/WIDTH RATIOS OF LEAVES OF *CUCURBITA DIGITATA*, *C. PALMATA* AND HYBRIDS FROM GREENHOUSE PLANTS AND FROM PLANTS SAMPLED AT VARIOUS FIELD LOCATIONS. THE LEAF MEASUREMENTS ARE THE AVERAGE OF 5 MATURE LEAVES FROM EACH COLONY

FIVE LOCATIONS ON U.S. HIGHWAY 95								
GREENHOUSE	DATELAND		YUMA	18 colonies				
	14 colonies	7 colonies	1	2	3	4	5	
digitata-like								
<i>C. digitata</i> #1	9.42 ± 1.66	11.29 ± 2.15						
<i>C. digitata</i> #2	8.34 ± .72	8.64 ± 1.03						
		7.14 ± .87		7.30 ± .82	7.41 ± 1.59	7.56 ± 1.62	6.95 ± .25	
intermediate								
	5.60 ± .72		6.25 ± .38		6.29 ± 1.04			
	5.07 ± .50				6.25 ± .70		6.28 ± .73	
F <sub>1</sub> ( <i>dig.</i> × <i>pal.</i> )	4.83 ± .39	4.80 ± .87	4.82 ± .37		5.62 ± .81	5.35 ± .40		
	4.62 ± .39		4.80 ± .87		4.87 ± .93			
		4.27 ± .27						
	4.32 ± .31							
	4.22 ± .59		3.96 ± .29		3.58 ± .92			
F <sub>1</sub> ( <i>pal.</i> × <i>dig.</i> )	3.87 ± .79			3.43 ± .20				
	3.65 ± .73			3.41 ± .45				
	3.56 ± .44							
	3.33 ± .39							
	3.09 ± .60							
	2.97 ± .38	2.85 ± .27						
palmata-like								
<i>C. palmata</i>	2.28 ± .27	2.19 ± .28	2.31 ± .15				2.10 ± .31	
			2.17 ± .19					
			2.09 ± .15					



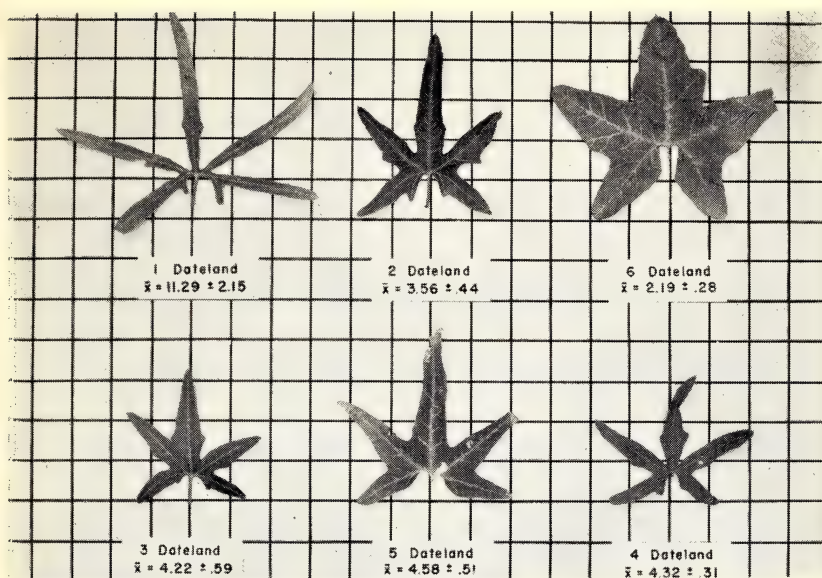


FIG. 4. Leaves from natural hybrids, Dateland; 1 (upper left) is "pure" *digitata*; 6 (upper right) is "pure" *palmata*; the remainder, 2-5, are intermediates.

mediates, but a majority of these plants were more like *C. digitata* than *C. palmata*. There was no noticeable trend in favor of one or another of the two species from north to south, nor did the individual sampling areas appear to be homogeneous for leaf type.

#### DISCUSSION

Two perennial, xerophytic species of *Cucurbita*, *C. digitata* and *C. palmata*, were successfully hybridized under controlled conditions. They produced fertile  $F_1$  and  $F_2$  progenies, indicating a marked degree of compatibility. Reasoning from this information, it was considered probable that natural hybridization might occur in locations where the ranges of the two species overlap. The area immediately east of the Colorado River, adjacent to the Arizona-California border and stretching north to south for a distance of 200 miles seems the most likely place for hybridization to occur. Before the search for natural hybrids could be profitably pursued, it was necessary to have a reliable morphological marker to indicate putative hybrids. The two species are nearly similar in vegetative, fruit and seed morphology, but there is a striking difference in one vegetative character, *leaf shape*. A ratio of the lobe length to lobe width was devised to describe numerically the leaves of the parent species and the hybrid between them.

Since these species are cross compatible and monoecious, we would anticipate considerable hybridization in nature if a suitable pollinator

were present. That such a pollinator is present was established by Hurd and Linsley (1964) in their scholarly studies of the squash and gourd bee of the genera *Xenoglossa* and *Peponapis*. The authors report that one species, *P. timberlakei*, is limited to *C. digitata* and *C. palmata* for its pollen and nectar supplies. Apparently *P. timberlakei* cannot use the pollen of other *Cucurbita* species even when available within its range. The infrequent, but severe rainstorms that cause flooding and erosion in this area could produce niches free from competition where young *Cucurbita* seedlings would have an excellent chance to become established. Thus four elements for successful natural hybridization are present: 1, compatible species; 2, overlapping ranges; 3, an efficient pollinator; and 4, a niche for the survival of the hybrids.

Using the leaf ratio index as a criterion it is apparent from field collections that natural hybridization exists along a narrow front roughly parallel to the Colorado River in western Arizona. We are suggesting the two species migrated into the area and subsequently hybridized. This area of the Colorado River basin is traversed by the Gila River and numerous dry washes all flowing westward toward the Colorado River. Violent summer and fall rains, although relatively infrequent, produce much flooding and erosion and would be capable of transporting fruits and seeds from south and east central Arizona toward the Colorado.

#### SUMMARY

1.  $F_1$  and  $F_2$  hybrid populations of *C. digitata*  $\times$  *C. palmata* were produced in the greenhouse. These hybrids were fertile, indicating the two species are compatible.

2. *Cucurbita digitata* and *C. palmata* are sympatric along a narrow front parallel to and directly east of the Colorado River, extending from the vicinity of Davis Dam in southern Nevada to San Luis in northern Sonora, Mexico.

3. The most conspicuous morphological difference between the two species is the structure of the leaf. *Cucurbita digitata* has five lanceolate lobes with the sinuses extending to the base of the leaf. *Cucurbita palmata* has five palmate lobes with sinuses extending about one-third the distance to the base. A ratio was devised to reflect this difference: thus *C. digitata* has a length width ratio of 10; *C. palmata*—2; and the  $F_1$  hybrid—5.

4. In the areas where the two species are sympatric we have sampled colonies in three locations and determined by leaf length to width ratios that natural hybridization has occurred.

5. We have shown that the elements for successful natural hybridization are present, i.e. compatible species, overlapping ranges, a specific pollinating insect, and niches for the survival of the hybrid seedlings.

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## MANZANITA CHAPARRAL IN THE SANTA ANA MOUNTAINS, CALIFORNIA

R. C. WILSON AND R. J. VOGL

A quantitative study of *Arctostaphylos glandulosa* Eastw. chaparral associations in the Santa Ana Mountains was undertaken during the years 1962 and 1963. This phytosociological study correlates numerical data with information on climate, soils, slope exposure, and elevation to estimate the stability, site preferences, and species associations for *Arctostaphylos glandulosa*.

Little consideration has been given to the quantitative aspects of chaparral associations dominated by *Arctostaphylos* species. Major attention has been given to *Adenostoma fasciculatum* H. & A. chaparral, a more widespread and lower elevation community. Extensive studies of *Arctostaphylos* chaparral have possibly been neglected because it is more restricted than *Adenostoma* chaparral, occurs at higher elevations which are often more difficult to reach, and is usually considered impenetrable. Since *Arctostaphylos* chaparral generally occurs at higher elevations, it does not present as many erosion, watershed, or fire problems and is considered of less economic, agricultural, or wildlife importance than chaparral types bordering grazing land, cultivation, or settlement.

The classic work of Cooper (1922) in central California is a floristic study of California chaparral (Delting, 1961). Cooper observed and commented on slope, exposure preferences, behavioral characteristics, humus accumulation, and evaporation ratios of *Arctostaphylos* associations as compared with other chaparral associations. Cooper cited 19 species of *Arctostaphylos* as components of chaparral and classified *Arctostaphylos* site requirements as intermediate between *Adenostoma fasciculatum* and coniferous forest.

Following Cooper's work, a number of studies were made of chaparral ecology, again mainly in *Adenostoma* communities. These include reports by Bauer (1936), Miller (1944; 1947), Sampson (1944), and Wells (1962). Sampson quantitatively studied chaparral succession in central and northern California. He indicated that pine suffered when associated with *Arctostaphylos* due to the greater potential of *Arctostaphylos* to recover after fire by resprouting or by seed germination. Some *Arcto-*



*staphylos* species survive fire by possessing fire-resistant basal burls while other species rely entirely on seeds that depend upon high temperatures for germination (Jepson, 1916). More recently, Wells (1962) correlated mosaic chaparral patterns with geological mosaics and disturbances around San Luis Obispo, California. He noted that the *Arctostaphylos* species *A. obispoensis* Eastw., *A. rudis* Jeps. & Wiesel., and *A. morroensis* Wiesel. & Schreib. had definite soil preferences for serpentine and unconsolidated siliceous sand and succeeded on soils where other plants were unable to survive.

Specific reference to the chaparral in the Santa Ana Mountains was made by Pequegnat (1951) who noted the plant species present, plant-animal associations, and weather conditions in the area. Three *Arctostaphylos* species are listed as present; *A. glauca* Lindl., *A. glandulosa*, and *A. pringlei* Parry var. *drupacea* Parry. He reported that *Garrya flavescescens* Wats., *G. fremontii* Torr., and *A. glandulosa* form an association above 4000 ft elevations.

Abrams (1951), McMinn (1939), and Wieslander and Schreiber (1939) have presented taxonomic descriptions of *Arctostaphylos*. These descriptions define the distribution of species and give clues to possible site preferences.

#### THE STUDY AREA

The Santa Ana Mountains are located in the southern California Peninsular Ranges, a complex of inland and coastal ranges, which extend through Riverside, Orange, and San Diego counties (Jahn, 1954). The Santa Anas are located 10 miles east of the City of Santa Ana, and are about 40 miles long extending southeasterly from the Santa Ana River. The entire range covers approximately 400 square miles varying in width from 4 to 13 miles. The crest with an average height of 3500 ft, is located some 20 to 25 miles from and parallel to the Pacific Ocean. Santiago Peak is the highest point (5860 ft) and Modjeska Peak is the only peak over 5000 ft in the Santa Ana chain.

The Santa Ana Mountains were elevated along the Great Elsinore Fault during the Pleistocene Period. The range has been broken into secondary blocks by further faulting processes, contributing to their rugged character. This range is tilted southwestward with the crest lying near the eastern limits. The east face is a battered fault scarp, drained by short streams. Santiago Creek is the main stream draining the mountains to the west (Hinds, 1952).

Pequegnat (1951) reports that the basement core is partly metamorphosed sediments and granitic intrusives. Along the north and south edges of the range, the ends of the basement core are surrounded by a complex of sedimentary clays, shales, and sandstones.

Close proximity to the sea moderates any climatic extremes in this winter-wet, summer-dry region. Pequegnat (1951) reports that 90% of the precipitation occurs from December to April. Snowfall is moder-



ate with the 3500 ft level as its lower limit. Most precipitation occurs within a belt between the elevations of 2000 and 4000 ft. Fog is common on the Pacific coast slopes in the spring and early summer. The prevailing winds that emanate from the southwest and west are interrupted only by hot, dry "Santa Ana", föehn winds which occasionally sweep down from the high desert.

The vegetational composition is as varied as the undulating topography. Major forms include coniferous forest of *Pseudotsuga macrocarpa* (Vasey) Mayr. and *Pinus coulteri* D. Don., and chaparral. The main vegetational type is chaparral, dominated by *Adenostoma fasciculatum* at lower elevations and by *Arctostaphylos glandulosa* at higher elevations.

The sample stands for this study were scattered over a 12 mile range within the boundaries of the Cleveland National Forest in the central part of the Santa Ana Mountains, and confined to areas of *Arctostaphylos* chaparral. The U.S. Forest Service, Santa Ana Ranger Station fire records show numerous fires for the Santa Ana Mountains since 1922, but fire disturbance has been absent from the study areas for at least 25 years.

#### METHODS

Sample sites were selected using the following criteria: 1. a lack of unnatural disturbances such as bulldozing, road building, and cutting, 2. no natural catastrophe such as fire within the last 25 years, 3. relatively homogenous areas of vegetation, 4. each site uniform in its elevation, slope, exposure, and soils, and, 5. a presence of mature, reproducing plants on established sites. Specimens of all species were collected and classied according to Munz (1959).

Each site was sampled quantitatively with a 100 ft line-intercept and a one-fortieth acre quadrat. The total number of feet intercepting the line was recorded for each species, including overlapping species. From this, relative per cent cover on the 100 ft line was calculated.

Each one-fortieth acre quadrat was placed adjacent to the line-intercept in a rectangle,  $100 \times 10.9$  ft. This quadrat was broken into four contiguous sections each  $25 \times 10.9$  ft. The number of individuals of each species was counted in each quadrat. An individual plant was any plant possessing a burl or trunk distinct from other burls or trunks. Relative per cent frequency, relative per cent dominance, and density of individuals per acre were calculated from the quadrat data. Values of relative per cent cover, relative per cent density, and relative per cent frequency were totaled to obtain importance values (I.V.) (Bray and Curtis, 1957). I.V.'s were derived for each species in each stand. Stands with similar floristic contents, as reflected by species I.V.'s, were classed together in association groups.

Additional measurements included height and number of stems per *Arctostaphylos* individual, elevation, exposure, degree of slope, and soil horizon depths. These measurements, in addition to observations on dis-

TABLE 1. AVERAGE IMPORTANCE VALUES (I.V.) FOR THE SPECIES IN EACH ARCTOSTAPHYLOS ASSOCIATION

Species	Association Oak Manzanita	Groups Manzanita Chamise	Manzanita Coulter Pine	"Pure" Manzanita
<i>Garrya fremontii</i>	12			
<i>Lonicera johnstonii</i>	3			
<i>Rhus diversiloba</i>	13			
<i>Rhus ovata</i>	4			
<i>Rhus laurina</i>	0.4			
<i>Ribes indecorum</i>	9			
<i>Prunus ilicifolia</i>		0.1		
<i>Yucca whipplei</i>		5		
<i>Pinus coulteri</i>			63	
<i>Cercocarpus betuloides</i>	15		1	
<i>Quercus dumosa, wislizenii</i>	153	3	3	
<i>Heteromeles arbutifolia</i>	2	2		4
<i>Adenostoma fasciculatum</i>	14	104	20	24
<i>Arctostaphylos glandulosa</i>	113	174	200	265
<i>Ceanothus crassifolius, leucodermis, tomentosus</i>	7	13	12	8

turbance, fire, growth habits, climate, and other meteorological data (Pequegnat, 1951), were used to determine factors influencing the distributions of plant species and associations.

The data were further analyzed by a mathematical summary which utilizes a coefficient of similarity (Bray and Curtis, 1957). With this coefficient, I.V.'s of the species from each stand were compared to those in all of the other stand sampled. In this way, stands were arranged according to their similarity or dissimilarity in species composition.

## RESULTS

The results obtained are based on the data summarized from 40 one-fortieth acre quadrats and 40 one-hundred ft line-intercepts.

Importance values (I.V.) were obtained for each species. These are summarized in Table 1 for stands classified into four *Arctostaphylos* chaparral associations. The associations; oak-manzanita, manzanita-chamise, manzanita-Coulter pine, and "pure" manzanita are named for the two leading plant dominants. Manzanita stands dominated only by *Arctostaphylos glandulosa* were called "pure" manzanita, since they were practically pure stands.

Table 1 lists the relative importance of each species in its association group and serves as a species presence list.

The two oak species in the oak-manzanita association are *Quercus dumosa* Nutt. and *Q. wislizenii* A. DC. This association group is the most heterogeneous in composition with 13 species represented. When compared to the two dominants, *Quercus* and *Arctostaphylos*, the other species are of minor importance. Among the minor species are *Cercocarpus betuloides* Nutt., *Adenostoma fasciculatum*, *Rhus diversiloba* T. & G., and *Garrya fremontii* Torr.

TABLE 2. AVERAGE NUMBER OF INDIVIDUALS PER ACRE OF THE IMPORTANT SPECIES IN EACH ARCTOSTAPHYLOS ASSOCIATION

Species	Association Groups			
	Oak Manzanita	Manzanita Chamise	Manzanita Coulter Pine	"Pure" Manzanita
<i>Garrya fremontii</i>	160			
<i>Lonicera johnstonii</i>	20			
<i>Rhus diversiloba</i>	80			
<i>Rhus ovata</i>	16			
<i>Rhus laurina</i>	4			
<i>Yucca whipplei</i>		7		
<i>Pinus coulteri</i>			320	
<i>Cercocarpus betuloides</i>	80		6	
<i>Quercus dumosa, wislizenii</i>	1040	3	19	
<i>Heteromeles arbutifolia</i>	4	2		28
<i>Adenostoma fasciculatum</i>	16	1308	24	160
<i>Arctostaphylos glandulosa</i>	800	2142	2443	3520
<i>Ceanothus crassifolius,</i> <i>leucodermis, tomentosus</i>	12	255	118	28
Totals	2232	3717	2,330	3736

In the manzanita-chamise association, few other species are present other than occasional individuals of *Ceanothus* spp. (including *C. crassifolius* Torr., *C. leucodermis* Greene, and *C. tomentosus* var. *olivaceus* Jeps.), and *Yucca whipplei* Torr. This association is the most xeric and occupies the lowest elevations studied.

The manzanita-Coulter pine association is dominated by *Arctostaphylos glandulosa* followed to a lesser extent by *Pinus coulteri* and *Adenostoma fasciculatum*. Again, a few individuals of *Ceanothus* are present.

The "pure" manzanita association is represented by the lowest number of species (four). The *Arctostaphylos* I.V. is high when compared with those of the other three species, of which *Adenostoma* is the most common.

The I.V.'s of *Arctostaphylos* increase as it is associated with *Quercus*, *Adenostoma*, *Pinus coulteri*, and "pure" stands respectively.

The number of individuals per acre for each species is summarized in Table 2 for the four associations. The total number of individuals of all species per acre ranges from 2232 in oak-manzanita to 3736 in "pure" manzanita. Manzanita-chamise and "pure" manzanita have approximately the same total number of individuals per acre. The density of *Arctostaphylos*, like the I.V.'s, increases as it is associated with *Quercus*, *Adenostoma*, *Pinus coulteri*, and "pure" stands. When the average number of stems per *Arctostaphylos glandulosa* individual (five) is multiplied by the number of *A. glandulosa* individuals per acre for each association, the range is from 4,000 stems per acre in oak-manzanita to 17,610 stems per acre in "pure" manzanita. The numbers per acre among the codominants is higher for *Quercus* in the oak-manzanita than it is for *Arctostaphylos*. With the exception of *Adenostoma* in the manzanita-chamise association, the other codominants are low when compared to *Arcto-*

TABLE 3. AVERAGE ABSOLUTE PER CENT COVER FOR THE SPECIES IN EACH ARCTOSTAPHYLOS ASSOCIATION

Species	Association Groups			
	Oak Manzanita	Manzanita Chamise	Manzanita Coulter Pine	"Pure" Manzanita
<i>Garrya fremontii</i>	3			
<i>Lonicera johnstonii</i>	0.3			
<i>Rhus diversiloba</i>	2			
<i>Rhus ovata</i>	2			
<i>Rhus laurina</i>	0.4			
<i>Ribes indecorum</i>	1			
<i>Prunus ilicifolia</i>		0.1		
<i>Yucca whipplei</i>		0.1		
<i>Pinus coulteri</i>			17	
<i>Cercocarpus betuloides</i>	7		0.1	
<i>Quercus dumosa, wislizenii</i>	59	2	1	
<i>Heteromeles arbutifolia</i>		0.4		
<i>Adenostoma fasciculatum</i>		30	3	4.6
<i>Arctostaphylos glandulosa</i>	26	67	80	94
<i>Ceanothus crassifolius,</i> <i>leucodermis, tomentosus</i>	1	3	2	0.6
Bare ground	6.6	5.7	9.3	2.6

*staphylos*. Subdominant species such as *Ceanothus* attained their greatest density in manzanita-chamise stands and to a lesser degree in manzanita-Coulter pine stands. *Garrya fremontii*, another minor species, was fairly dense in the oak-manzanita association.

Table 3 is a summary of absolute per cent cover for the species in the four associations. This is calculated by dividing the total feet of cover (intercept on the 100 ft line) for each individual by the total length of the transect taken and is expressed as per cent. Absolute per cent cover can be used as an indicator of dominance for each species. These figures are proportionately comparable to the density and I.V. data. An additional figure is the per cent bare ground or percentage of the transect devoid of plant cover. The manzanita-Coulter pine association has the greatest percentage of bare ground and the "pure" manzanita association has the least with a 94% cover of *Arctostaphylos glandulosa* and a 2.6% intercept of bare ground. The bare ground figures for all four associations are low (less than 10%) verifying that plant growth is dense in all four associations.

The 40 stands, each designated as an association, were arranged graphically on a target diagram to summarize and compare slope and exposure data (fig. 1). The preferences for slope show that *Arctostaphylos glandulosa* formed solid stands on gentle slopes ( $10-30^\circ$ ), mixed with *Adenostoma fasciculatum* on a wide variety of slopes, and occurred with *Pinus coulteri* on steep slopes ( $28-35^\circ$ ). *Quercus* species and *Pinus coulteri* locate most successfully on the steeper slopes ( $30-40^\circ$ ) (figs. 2 and 3).

Slope is related to soil depth and the presence of organic matter. The gentle slopes of "pure" manzanita had the deepest and richest soils, the intermediate slopes of manzanita-chamise had shallow soils often lacking



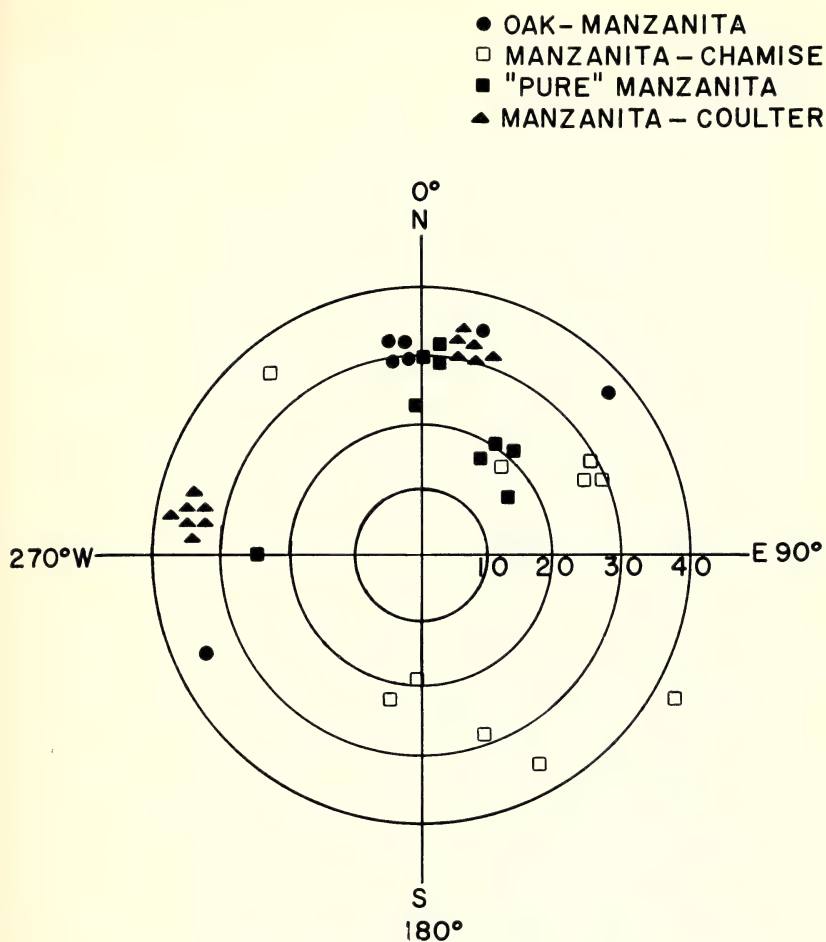


FIG. 1. Slopes and exposures of *Arctostaphylos* association stands. Each circle represents 10 degrees of slope with the smallest circle representing 0–10 degree slopes. Compass directions indicate exposure.

in organic matter, and the steep slopes of manzanita-pine had a general absence of soils.

A gradient of vegetation often follows an elevational gradient, but in the Santa Ana Range, this gradient is highly modified by exposure. Considering exposure preferences, "pure" manzanita was most often located on the north and northeasterly-facing slopes. Manzanita-pine and oak-manzanita were also found on north-facing slopes. Manzanita-chamise was scattered on both north and south-facing slopes, but occurred as the dominant cover on the southerly faces on the seaward side of the main divide. The west faces are warm-xeric with chamise going to the moun-

tain crest. On the colder north exposures, *Adenostoma* does not succeed to the top but generally terminates in a chamise-manzanita association. The east or inland faces support *Cercocarpus betuloides* and *Quercus* species which form a solid cover mixing with *Arctostaphylos* only at the crest.

Stands situated on southwesterly slopes were generally on decomposed granite (quartzite and potash feldspar), while northerly and easterly slope stands were usually on a sedimentary complex of shale and fine clay.

In each plant association depths of soil horizons were measured. Litter ( $A_0$ ) of oak-manzanita stands averaged 1 inch in depth which is less than in any other association. This may be due to a rapid rate of decomposition since the humus layer ( $A_1$ ) averages 6 inches in depth. Chamise-manzanita stands had an average  $A_0$  of 1.5 inches. Slow decay resulted in a shallow average  $A_1$  of 0.6 inches. These stands are on drier slopes with *Adenostoma* providing little cover or soil protection. Pine-manzanita stands had an average  $A_0$  depth of 2.5 inches and an  $A_1$  of 1.5 inches. "Pure" manzanita stands produced the deepest average  $A_0$  of 3.7 inches, with a rich average  $A_1$  horizon of 5 inches.

These results suggest that "pure" manzanita produces and accumulates more litter and organic matter than when mixed with *Adenostoma* or *Pinus coulteri*, and produces excellent humus when associated with *Quercus* on moist sites. As a member of broadleaf chaparral *Arctostaphylos* is a good soil producer, especially when compared to needleleaf *Adenostoma*.

*Arctostaphylos glandulosa* assumes different physiognomic characteristics growing under various conditions or associated with different species.

In manzanita-chamise stands *Arctostaphylos glandulosa* grows to a maximum height of about 6 ft. Branches are thin with numerous laterals and dead twigs remaining on the main stems beneath the surface canopy.

In oak-manzanita chaparral the *Quercus* species and *Arctostaphylos* do not mix but grow as separate aggregations (fig. 3). In other respects the growth character of *A. glandulosa* is much like that in manzanita-chamise stands. Small open areas within *Quercus* clumps are often filled by *Arctostaphylos* suggesting that it can grow in oak litter, but perhaps not in oak shade or deep oak litter.

Beneath *Pinus coulteri*, *Arctostaphylos glandulosa* stems grow prostrate and parallel to the ground. At the edge of the pine canopy, the stems respond phototropically and become vertically orientated. The tallest *A. glandulosa* individuals (14 ft) were measured in this association.

*Arctostaphylos* in pure stands forms a dense mass of branch meshwork (fig. 4). This type of growth produces a uniform canopy. Individuals grow from 10 to 12 ft in height, with stout, twisted stems lacking twigs beneath the canopy.



FIG. 2. A manzanita-Coulter pine association on a northeast slope. *Arctostaphylos glandulosa* occupies the gentler slopes and the *Pinus coulteri* occupies the steeper slopes of the drainage pattern.

In all associations, *Arctostaphylos* stems were observed to grow at right angles to the slope or to exhibit a down-hill tendency.

*Heteromeles arbutifolia* M. Roem., like *Quercus*, grows adjacent to *Arctostaphylos* with few individuals intermixing. Most *H. arbutifolia* plants grow on steeper sites in isolated clusters away from *Arctostaphylos*. The *Ceanothus* species appear to be rapidly declining. Most of the *Ceanothus* plants encountered were either dead or failing. Surviving plants were usually taller than the surrounding *Arctostaphylos* indicating that the shading competition of *Arctostaphylos* may hasten the death of the relative short-lived *Ceanothus*. *Garrya* observed in association with *Arctostaphylos* exhibited growth habits similar to those of *Arctostaphylos*.

Herbaceous plants were generally absent in the understory of *Arctostaphylos glandulosa* chaparral. Annuals, perennials, and grasses were found only on disturbed sites, along road cuts, or on fire breaks in this chaparral.

#### DISCUSSION

For ease of comparison, the community approach categorizes the natural vegetation in the mind of the investigator. In reality, the vegetation is not always as neatly segmented or defined by sharp borders and actually varies gradually and continuously, both in time and space. The vegetation in this study is summarized into four associations. These associations become convenient tools in isolating segments and lumping floristic similarities for the purpose of summarizing trends.

The oak-manzanita association has the greatest variety of species, perhaps because it is found on steep and rocky terrain which provides a great variety of environmental conditions and thus a number of ecological niches.

In comparing the role of competition between *Pinus coulteri* and *Arctostaphylos glandulosa* it appears as though *P. coulteri* cannot successfully compete with the fire-resprouting *A. glandulosa* in the face of repeated burning. After fire *P. coulteri* establishes itself in rivulets, channels, and erosion patterns where the burls of *A. glandulosa* have been washed out or in areas too steep or unstable for *A. glandulosa* to persist. Manzanita-Coulter pine associations contained little *Adenostoma* and even less *Ceanothus*. The lack of living *Ceanothus* is attributed to the lack of disturbance in the area for at least the last 25 years (Hadley, 1961; Patric and Hanes, 1964). *Ceanothus* is known to be relatively short-lived and to require fire or other disturbances to reproduce (Quick and Quick, 1961). Accounts of competition between *Pinus coulteri* and *Arctostaphylos* species indicate that often with fire, the association may give way to a *Ceanothus-Arctostaphylos* association or "pure" manzanita (Cooper, 1922; Sampson, 1944; Zobel, 1953).

The "pure" manzanita association occupies the most gentle slopes, has the highest number of individuals per acre, and provides the most complete cover (fig. 4). The cover produces a canopy equal to that of a forest (Cooper, 1922) and demonstrates the greatest control of the ground surface.





FIG. 3. A gentle north slope supporting "pure" manzanita. The steeper surrounding slopes were covered mainly with *Quercus dumosa* and *Q. wislizenii*.

The dense, tight growth and closed canopy of *Arctostaphylos glandulosa* have several marked affects on the microenvironment of the stands. Direct soil insolation is prevented and subsequent drying is retarded. Evaporation from the soil surface is reduced producing semi-mesic conditions. The closed canopy tends to eliminate competition of other species as evidenced by the lack of seedlings or herbaceous plants in the understory. Strips of *A. glandulosa*, in which canopy cover was mechanically removed by cutting, contained many shade intolerant

shrub seedlings and herbaceous plants. The umbrella-like canopy affords protection against raindrop compaction and erosion. However, erosion by rain is not as important in the Santa Ana *Arctostaphylos* belt as it may be elsewhere. The major forms of precipitation in this "cold" chaparral are fog-drip, freezing moisture (hoar frost), and snow.

The high density of stems retards slope erosion, aids water infiltration, and adds large quantities of litter in the form of twigs and leaves, thus influencing soil genesis. This litter is not readily washed, wind-blown, or lost by desiccation as it is in *Adenostoma* chaparral. More organic matter is accumulated and retained in *Arctostaphylos* chaparral than in any of the other Santa Ana chaparral types. The mesic nature of the soil aids in rapid decay and incorporation of organic material with mineral soil (by chaparral comparisons), producing a pronounced A<sub>1</sub> soil horizon (Wilson, 1963). *Arctostaphylos glandulosa*, then, is a good soil builder and watershed cover as compared to other chaparral types.

Cooper (1922) noted that *Arctostaphylos* species showed a preference for degree of slope and became established as a dominant on the most gentle slopes available in a favorable site. He also noted that *Arctostaphylos* gave way to oak and pine on steeper slopes. Similarly, *A. glandulosa* in the Santa Ana Mountains formed solid stands on the gentlest north and northeast slopes above 3200 ft elevation in the presence of marine air and grew with *Pinus coulteri* and *Quercus* species on the steeper slopes (fig. 1). Of the steepest slopes (40°–100°), the xeric, unstable types with running talus were occupied by *Quercus* while the more mesic, stable precipices were covered by *Pseudotsuga macrocarpa*. Occasional *Arctostaphylos* plants grew in rocky crags or on steep cliffs but did not form solid stands. The germination, seedling, and rooting requirements of *Pinus coulteri*, *Pseudotsuga macrocarpa*, and *Quercus* species may enable them to dominate pioneer and unstable sites of steeper slopes, rocky outcrops, or slides. *Pinus coulteri* is also found on gentle slopes but is limited, possibly because it cannot successfully compete with the burl-sprouting *Arctostaphylos glandulosa*. In many areas, *A. glandulosa* with the aid of fire, appears to be a potential successor of pine. Barring disturbance, established *P. coulteri* might gradually replace the apparently long-lived *Arctostaphylos* stage of fire succession. However, succession is complicated by periodic fires and subsequent erosion, as well as by fungus and insect damage or kill to the *P. coulteri* (Pequegnat, 1951). Further research is necessary to determine precisely the relative successional positions of *A. glandulosa* and *P. coulteri*.

The exposure of slope is another important factor which affects the establishment of *Arctostaphylos*. The most dense stands are on north-facing slopes, particularly those slopes reached by the late winter, spring, and early summer fogs. These fogs strike the upper ocean-facing slopes and crests. As they billow over the crest, through openings, and across lower ridges, they afford moisture to some upper and northern slopes not





FIG. 4. The interior of a "pure" manzanita stand with the typical high density of stems and heavy cover of solid *Arctostaphylos glandulosa*.

directly exposed to the sea. In addition, these northern slopes receive less solar insolation. Since the north faces are not directly exposed to the prevailing westerly winds, they are also subjected to less transpiration stress. Coulter pine-manzanita is correlated with the presence of fog belt areas on northern exposures.

East-facing slopes are in a fog and rain shadow and are subjected to descending winds with greater evaporation-transpiration stress for

plants. These east slopes support *Quercus-Cercocarpus* chaparral with only scattered individuals of *Arctostaphylos* near the crest.

Amplitudes of tolerance and successional relationships are implied from the results of the comparisons of similarity and dissimilarity of stands outlined in the Methods. Each species associated with *Arctostaphylos* has its own amplitude of tolerance or range of ecological requirements and no two amplitudes are the same for any of the species. Stands with a predominance of *Quercus* are the most dissimilar from those dominated by *Arctostaphylos*. Therefore, *Quercus* and *Arctostaphylos* are considered the most dissimilar in their ecological requirements. *Arctostaphylos* and *Pinus coulteri* are the most similar. Within the Santa Ana Mountains, *Quercus* species find optimum growth conditions in hot, dry environments while *Arctostaphylos glandulosa* and *Pinus coulteri* prefer cooler and semi-mesic environments. *Adenostoma* differs from *Arctostaphylos* in that it reaches greatest importance on hot, xeric sites exposed to marine air. *Ceanothus*, although suffering from old age, demonstrated the widest amplitude of tolerance of any species in the *Arctostaphylos* chaparral associations, occurring with *Adenostoma*, *Pinus*, and *Quercus*.

All of the species vary gradually and continuously on an elevational gradient. That is, none of the species start or end abruptly at a certain elevation. This gradient is greatly modified by exposure, slope, soils, fire, and air currents. However, optimum conditions as reflected by the greatest numbers are found for *Adenostoma* at lower elevations, and for *Arctostaphylos* and *Pinus* at the highest elevations.

#### SUMMARY

Little quantitative or phytosociological study has been made of *Arctostaphylos* chaparral in the southern California Peninsular Ranges. In this study, it is proposed that *Arctostaphylos glandulosa* is a significant unit in the Santa Ana Mountain "cold" chaparral as; 1. a forest (*Pinus coulteri*) competitor, 2. a potential factor in watershed management, 3. an important contributor in soil genesis, and 4. a possible agent of erosion control.

Importance values derived from the line-intercept and quadrat data are used to classify the 40 stands sampled into four associations; 1. oak-manzanita, 2. manzanita-chamise, 3. manzanita-Coulter pine, and 4. "pure" manzanita. These *Arctostaphylos* associations are designated by dominant and codominant species present and are all found above 3200 ft elevation in the Santa Ana Mountains. The results indicate that *Arctostaphylos*; 1. becomes a significant dominant when associated with *Adenostoma fasciculatum* at upper elevations on south- and west- facing slopes and at lower elevations on north- and northeast- facing slopes, 2. with fire is a potential successor of *Pinus coulteri* on the north and northeast slopes and ridges, 3. is associated with *Quercus* aggregations but demonstrates mutual exclusion, and 4. forms solid stands on gentle north and northeast slopes above 3200 ft in the presence of marine air.



Plant growth is dense in all four associations with less than 10% bare ground in any association.

A comparison of the species composition of the 40 stands suggests that *Quercus* and *Arctostaphylos* are the most dissimilar in ecological tolerance and that *A. glandulosa* and *Pinus coulteri* have similar requirements. *Quercus* species attain their greatest growth and density in hot, dry environments and *Arctostaphylos* and *Pinus coulteri* find optimum conditions in cooler and semi-mesic environments.

Factors of altitude, exposure, slope, fire, and marine air determine the extent to which *Arctostaphylos glandulosa* successfully competes with associated species to become the dominant plant in the "cold" chaparral of the upper elevations in the Santa Ana Mountains.

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## REVIEWS

*Flora Europaea*. Edited by T. G. TUTIN, V. H. HEYWOOD, N. A. BURGESS, D. H. VALENTINE, S. M. WALTERS, and D. A. WEBB. Vol. 1. Lycopodiaceae to Platanaceae, xxxii + 464 pp., 5 maps. Cambridge Univ. Press. 1964. \$16.00.

From the beginning in 1956, the *Flora Europaea* project has been broadly cooperative, highly organized, and based on a premise that much value lies in having a flora completed in the shortest possible time. Volume I, contributed by 51 authors representing 14 nationalities, provides in part the first synthesis of the European flora on a continental scale and, much to the benefit of most American botanists, in a *single* language. The remaining three volumes are planned for publication within the next eight years. The area covered, shown by maps, extends from Spitzbergen to the Azores and eastward through the Mediterranean (including Sicily, Crete, European Turkey, Crimea, and northern shore of Caspian Sea) to the Ural Mountains.

Readers should be able to name to subspecies any fern (or fern ally), conifer, or flowering plant which grows wild in Europe and also those commonly cultivated. The descriptions are brief but adequate and often are followed by a cogent statement regarding variability and relationships to other taxa—a strong feature. Author or editor credit is provided for each generic treatment. Chromosome numbers sensibly are given only if determined from materials of known wild European origin. A check-list of references will be published separately which ought to explain some new reports such as  $2n = 22$  for *Meconopsis cambrica*. Sections, subgenera, and subfamilies appear where appropriate in the text. All families to be treated in the four volumes are keyed in Volume I. The sequence is Englerian except that monocots will come last. Filicopsida are divided into 21 families. Molluginaceae, Tetragoniaceae, and Parnassiaceae will seem strange to Americans. Paeoniaceae follows Ranunculaceae, Fumariaceae is submerged. *Mahonia* is separated from *Berberis*. *Platanus acerifolia* is considered a synonym of *P. hybrida* Brot. *Raphanus raphanistrum* is divided into five subspecies; *Brassica rapa* L. is favored over *B. campestris*, showing that California botanists have something still to learn. Of very minor moment, Capparaceae is conserved over Capparidaceae and the perigynous condition of *Eschscholzia* was overlooked.

The format should satisfy nearly everyone and there are useful dividends such as the list of basic or standard floras of the region, the list of families in Volume I, and the lists of titles of books and periodicals cited in the text. An index to signs, abbreviations, and explanatory notes, as well as a glossary of technical terms and some English-Latin equivalents are printed on blue paper for quick finding. The only suggestion that I dare make is that type species or lectotype species for genera ought to have been indicated at least when a member of the flora.

Many years will pass before the full significance of the *Flora Europaea* project can be known. Undoubtedly many European botanists, besides the contributors, will be stimulated to look once again at the plants in their own backyards. The numerous statements of compromise in this text point out many interesting problems which call for more detailed study. Instead of bringing floristic researches to a close, the *Flora* surely will be the starting point for an entirely new look at the plants of Europe. With this major effort recently completed, the floristic gaps in the northern hemisphere stand almost as a challenge. Here is a model, which ought

to be in every practicing taxonomist's office, and perhaps it is time to think seriously about a *Flora North America*.—WALLACE R. ERNST, Smithsonian Institution, Washington, D. C.

## NOTES AND NEWS

**ARCEUTHOBIUM DOUGLASII IN NEVADA AND WYOMING.**—The Douglas-fir dwarf-mistletoe, *Arceuthobium douglasii* Engelm., is one of the most widely distributed members of the genus in North America, ranging from southern British Columbia (J. Kuijt, Natl. Mus. Canada Bull. 186:134-148. 1963) south to Durango and Nuevo León in Mexico (F. G. Hawksworth and D. Wiens, Brittonia, in press). Gill (Trans. Conn. Acad. 32:111-245.1935) recorded this species in all of the eleven Western States except Nevada and Wyoming. Recently *A. douglasii* was discovered on *Pseudotsuga menziesii* (Mirb.) Franco in these two states by R. S. Peterson of the U. S. Forest Service. Nevada. White Pine Co.: NE slope of Wheeler Peak, W of Baker, *Peterson* 63-337. Wyoming. Lincoln Co.: Wolf Creek Campground, Snake River, Targhee National Forest, *Peterson* 62-64 (RM); Teton Co.: 4 miles E of Idaho border on Teton Pass Road, *Peterson* 62-12 (RM). Specimens of the above are in the herbarium of the Rocky Mountain Forest and Range Experiment Station. *Arceuthobium douglasii* does not occur in many areas where *Pseudotsuga menziesii*, its principal host, is found. It has not been observed in northern Colorado, central Wyoming, central Montana, Washington or Oregon west of the Cascades except in southern Oregon, or in California south of Siskiyou and Shasta counties (J. Kuijt, Madroño 15:129-139. 1960).—FRANK G. HAWKSWORTH, U. S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Colorado State University, Fort Collins.

**WASHOE PINE ON THE BALD MOUNTAIN RANGE, CALIFORNIA.**—Until recently Washoe pine, *Pinus washoensis* Mason & Stock., was known only from its type locality, a small area on the east slope of Mount Rose, southwest of Reno, Nevada (Madroño 8:61-63. 1965). In 1961 Haller (Madroño 16:126-132) reported an extensive uncut stand in the southern Warner Mountains, in the northeastern corner of California. Both stands have certain features in common: they occur at higher elevations (7000-8000 ft) than the closely related *P. ponderosa* Laws., and they front on the sagebrush plains of the Great Basin at the eastern edge of the Sierra Nevada mixed-conifer forest.

During the summer of 1964 we encountered Washoe pine in the Bald Mountain Range, about 20 miles northwest of the Mount Rose stand and 100 miles south of the Warner Mountains stand (UC, and conifer herbarium of the Institute of Forest Genetics, Placerville.) We looked for it there because this range is the most extensive area of high-elevation forest fronting the sagebrush plains between Mount Rose and the Warner Mountains. The 5-mile-long crest of the Bald Mountain Range is from 8000 to 8760 ft in elevation, is oriented in a NNW-SSE direction, and forms part of the easternmost ridge of the Sierra Nevada. Its high point, Babbitt Peak, is at 39° 36.1' N. latitude and 120° 06.2' W. longitude.

We examined only the northern part of the range, from Babbitt Peak to a point about 3 miles northwest of the peak where the ridge drops off sharply to the north. Washoe pine is mostly confined to the top of the ridge, but is occasional in the *Cercocarpus ledifolius* Nutt. scrub on the west slope and in the *P. monticola* Dougl. forest on the east slope. The other common trees on the ridge are *Abies concolor* (Gord. & Glend.) Lindl., *Juniperus occidentalis* Hook., and *Populus tremuloides* Michx. *Pinus jeffreyi* Grev. & Balf. and *A. magnifica* A. Murr. are present but rare.

This Washoe pine stand consists of only a few hundred trees. The pines on the ridge-top are mostly wind-deformed, but occasional trees on the east slope range up to about 3 ft in diameter at breast height and 90 ft in height.

Flowering had just begun when we visited the area on July 4. The species can



be easily distinguished from *P. ponderosa* by the color of its pollen cones and developing second-season seed cones. In Washoe pine both kinds of cones are reddish-purple to purplish-black, in contrast to the red pollen cones and green seed cones that characterize *P. ponderosa* throughout most of the central Sierra Nevada region.

This stand occurs at higher elevations than the other known stands of Washoe pine. All trees that we encountered were at elevations of 8300 to 8600 ft, and it is doubtful if either the Mount Rose or the Warner Mountains stand extends much above 8000 ft. Unlike the other two stands, the Bald Mountain stand appears to be remote from *P. ponderosa*, and may represent *P. washoensis* in a relatively undiluted form.—W. B. CRITCHFIELD, Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Berkeley, and G. L. ALLEN-BAUGH, Berkeley.

The following publications are of interest:

*Secondary Phloem in the Pinaceae*. BY LALIT M. SRIVASTAVA. University of California Publications in Botany 36:1–142. University of California Press, Berkeley and Los Angeles. 1963. \$3.00.

*Plan's of Arches National Monument*. BY BERTRAND F. HARRISON, STANLEY L. WELSH, AND GLEN MOORE. Brigham Young University Science Bulletin, Biological Series 5:1–23. Provo, Utah. 1964.

*An Annotated Checklist of Cultivated Palms*. BY HAROLD E. MOORE, JR. Principles 7(4):119–182. Available from the Palm Society, 7229 S.W. 54th Ave., Miami, Florida 33143. 1963. \$2.00.

*100 Desert Wildflowers in Natural Color*. BY NATT N. DODGE. 64 pp., 100 colored photographs. Southwest Monuments Association, Globe, Arizona, 1963.

*Common Edible and Useful Plants of the West*. BY MURIEL SWEET. 66 pp., 116 line drawings. Naturegraph Co., Healdsburg, California. 1962. \$1.00.

*Flowers and Ferns of Muir Woods*. BY GLADYS L. SMITH AND DRAWINGS BY JEANNE R. JANISH. 32 pp., 1 map, 1 black and white photograph, 12 colored photographs, 60 line drawings. Muir Woods Natural History Association, Muir Woods National Monument, Marin Co., California. 1963.

*The Conifer Walk*. BY P. H. BRYDON. 32 pp., illustrated. Strybing Arboretum Society, Golden Gate Park, San Francisco. 1964. This is a guide to the conifers in the Strybing Arboretum.

*Flora of West Virginia*. Introductory Section and Part IV. BY P. D. STRAUSBAUGH AND EARL L. CORE. West Virginia University Bulletin 65(3–1):xxxi; 65(3–2):vi + 861–1075. Morgantown, West Virginia. 1964. These two parts complete the *Flora of West Virginia*, the first part of which was published in 1952.

*An Annotated Catalogue of Plants from Window Rock, Arizona*. BY V. L. BOHRER AND M. BERGSENG. Navajoland Publications, Navajo Tribal Museum, Window Rock, Arizona. ii + 29 pp. 1963. \$0.25.





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CLINAL PATTERNS IN FROND ANATOMY  
OF POLYPODIUM

ROBERT M. LLOYD

Variability in frond anatomy of *Polypodium californicum* Kaulf. has been known as early as Eaton's (1879) monograph delineating two varieties, var. *kaulfussii* D. C. Eaton with coriaceous fronds and var. *intermedium* (H. & A.) D. C. Eaton, a more herbaceous inland form. He reported the former growing usually on rocks near the sea and stated: "The texture of fronds from inland localities is rather thinner than in *P. vulgare*, and the veins are more easily seen; but plants from the sea-coast . . . have a firmer frond, and less conspicuous veins," the latter, var. *kaulfussii*, "runs by gradation into the inland form." Kendall (1923) presented evidence for retention of the varieties but stated that the two forms vary within the same morphological limits except for the extremely leathery texture of var. *kaulfussii*. Lloyd (1962) found frond texture to change from herbaceous to coriaceous as a function of distance from the ocean.

Although the phenomenon of anatomical plasticity in relation to the environment has been frequently dealt with, few studies have shown it to occur in a clinal pattern and even fewer studies have offered quantitative anatomical data to demonstrate the actual nature of this change. Shields (1950) summarizes much of the work which has been done relating specific influences of the habitat to morphology. This paper presents an analysis of five populations of *P. californicum* growing at Pt. Reyes, California.

The author extends his grateful thanks to Sherwin Carlquist, H. G. Baker, R. W. Cruden, F. Rickson, and D. M. Hutt for their critical appraisal of the manuscript and to Rancho Santa Ana Botanic Garden and Duke University for the use of their facilities.

**METHODS AND MATERIALS.** Fronds were collected in the field at five locations (A-E. Lloyd 567, 568, 569, 570, 571, RSA) during January 1961, and the longest pair of pinnae were killed and fixed in formalin-aceto-alcohol (Johansen, 1940). Material was infiltrated, embedded, and sectioned at 12-15  $\mu$  according to the usual paraffin techniques. Sections were stained with Northen's modification of Foster's method (Johansen, 1940) and mounted in Canada Balsam. Surface characters were measured on preparations made by infiltrating and mounting 10 mm squares of dried material in water. Observations were made from transverse sections of pinnae on both cells and tissues to determine variation in each and provide evidence for the nature of anatomical distinctions.

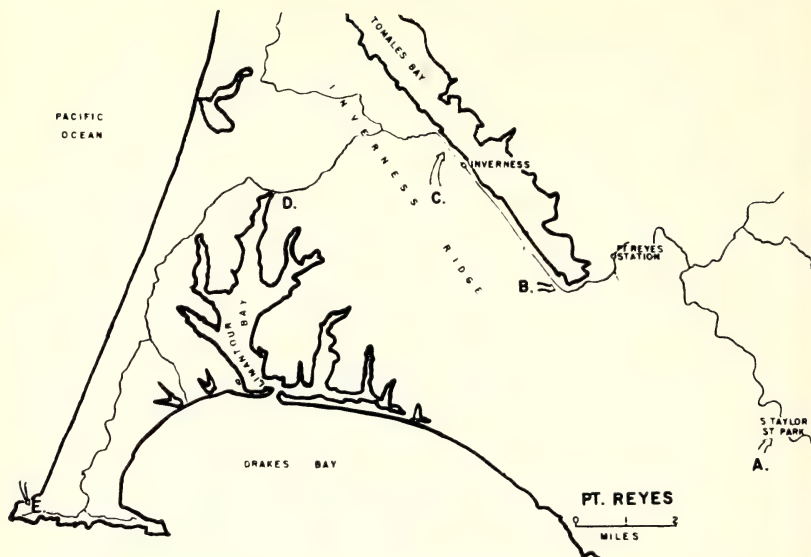


FIG. 1. Map of the Pt. Reyes region showing locations of populations A to E.

**ECOLOGY.** Pt. Reyes Peninsula, extending 12 miles from the mainland of Marin Co., California, is directly exposed to ocean influences on two sides (fig. 1). Forested areas in more protected regions are gradually replaced by coastal scrub and grassland communities closer to the shore. This change in vegetation is accompanied by higher wind velocity and relative humidity. The topographic relief in relation to the prevailing wind thus defines a mosaic of micro-habitats, but one that changes to greater exposure as the wind assumes dominance over the topography near the coast.

Fronds of *P. californicum* are drought-deciduous unless ground water is available. The summer period, therefore, during which the wind velocity and relative humidity are at their highest on the coast, will have little or no effect on frond characteristics.

The five populations dealt with in this paper are summarized below:

Population A. Fronds of *P. californicum* were collected 2.2 miles east of the entrance to Samuel P. Taylor State Park on a protected road-bank under deep shade of *Sequoia sempervirens*. This location is characteristic of many forested areas of the region in which large herbaceous fronds develop.

Population B. Plants from this location, 1.4 miles west of Pt. Reyes Station on California highway 1, were restricted mainly to moss-covered tree trunks in the moderate shade of *Umbellularia californica* and *Pseudotsuga menziesii* and were in close proximity to Tomales Bay.



Population C. This population, 0.9 miles west of Inverness, is from a habitat similar to but more open than that of population B. The same dominant trees are present. *Polypodium californicum* was found growing both epiphytically and in soil in a predominantly fern understory in moderate shade.

Population D. Plants were collected 5.3 miles west of Inverness by the side of the road to the Pt. Reyes lighthouse. In this area there are no trees and the ferns were found on moss-covered rocks of a north-facing road bank, shaded only part of the day. Associated species were *Mimulus guttatus*, *Scrophularia californica*, *Polystichum munitum*, *Stachys*, and *Rubus*.

Population E. Just north of the lighthouse gate at the southern tip of Pt. Reyes Peninsula, *P. californicum* is found on top of the bluffs above the ocean growing in full sun, only around and under small shrubs of *Vaccinium ovatum* and *Gaultheria shallon*. These species, along with *Lupinus arboreus*, are the dominant shrubs in the coastal grassland. Ferns were usually found on the leeward side of the shrubs where they were partially protected from ocean winds.

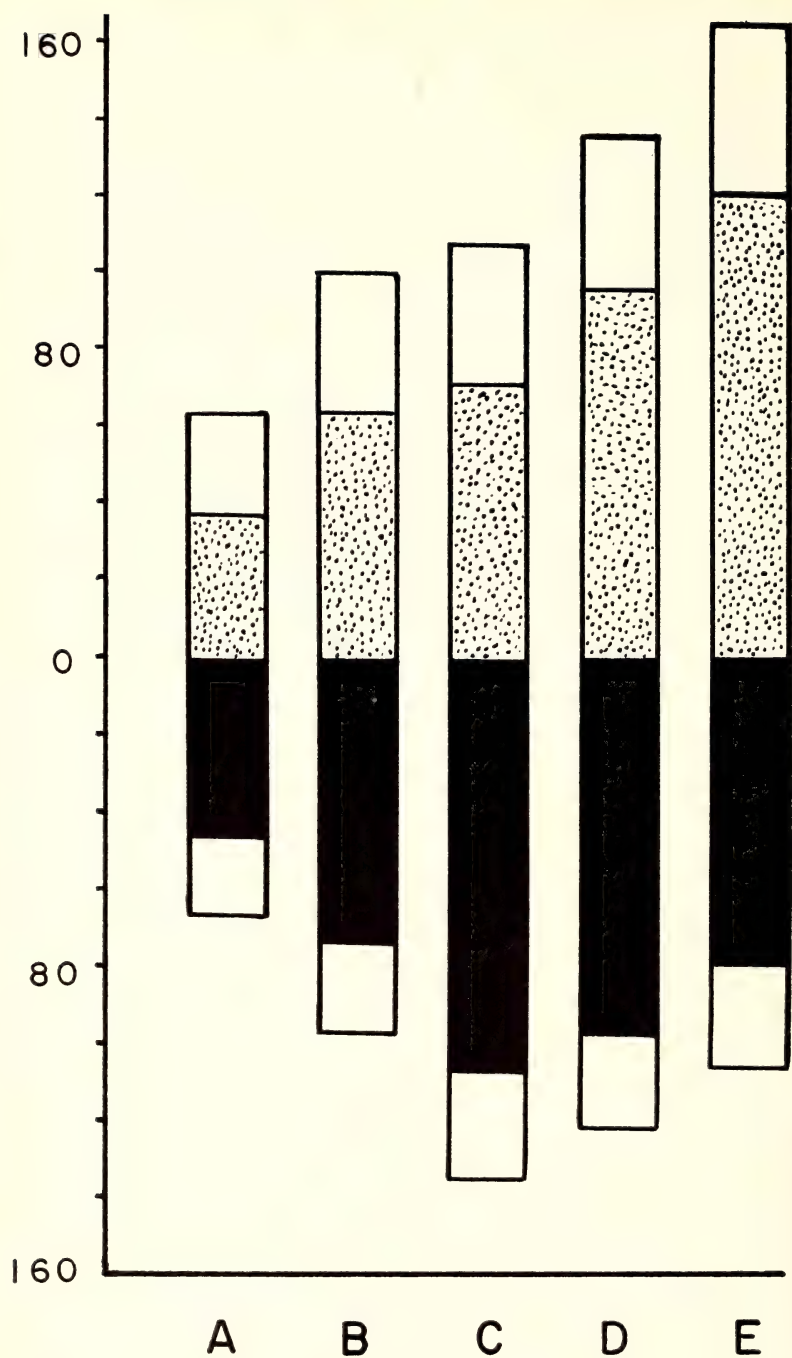
A related species, *P. scouleri* Hook. & Grev., is very rare at this locality but is found in abundance at lower elevations on the bluffs. There is some evidence of hybridization between this species and *P. californicum* in these latter localities (Lloyd, 1962; 1964).

RESULTS. Data from this study are summarized in Tables 1 and 2.

Fronds of *Polypodium* are bifacial but there is no great difference in cell size and shape in the palisade and spongy tissues as is the case in many mesomorphic dicotyledonous plants. For this reason it is sometimes difficult to demarcate tissues. In transverse section, the abaxial cells of the spongy layer are arranged with their long axes parallel with the frond surface. Many air spaces are present. In contrast, the adaxial cells or the palisade layer are very compactly arranged. In both layers there are fewer intercellular spaces near veins, producing a centric arrangement of cells in the chlorenchyma. Virtually all of the cells of the epidermis and mesophyll, except those of the vascular system, contain chlorophyll. Stomata are confined to the abaxial surface of the frond. Trichomes occur abundantly on the latter surface and are bicellular, unbranched, and glandular.

Investigation of fronds has demonstrated a gradient in thickness from a minimum of 128  $\mu$  in population A to a maximum of 260  $\mu$  in population E. The change in proportion of the various tissues due to increased exposure follows a well established pattern reported in higher plants (Turner, 1923; Weaver and Clements, 1929).

Computation of relative proportions of the tissues of an entire frond shows an increase in the palisade layer as the coast is approached (table 1). There is a corresponding increase in the spongy layer until a maximum is reached at population C (fig. 2) although the mean size of the spongy tissue is larger than the palisade in all populations except



E. Epidermal tissue show a range (A-E) from 20 to 13% on the adaxial cells and 14 to 10% on the abaxial side accompanying the grades of the mean thickness of the palisade. However, investigation of individual cell size of epidermal layers shows that both increase in depth and diameter in direct relation to coastal influences (table 2). This is most apparent on the adaxial side which is usually more directly exposed to sun and wind. In both cases the most striking increase is in the diameter of the cells.

Depth of individual cells in the palisade mesophyll gradually increases from a mean of  $25\ \mu$  in population A to  $32\ \mu$  in E. The diameters of these cells show a corresponding but greater increase from  $31\ \mu$  at A to  $51\ \mu$  at E. In both instances, however, the largest cells observed were in population D. Cell depth of the spongy mesophyll increases from a mean of  $20\ \mu$  in population A to  $28\ \mu$  in E. Diameters indicate a much more marked change with an average increase of  $26\ \mu$  from population A to E. In both layers, but especially in the spongy mesophyll, an obvious decrease in the proportion of intercellular spaces characterize plants from near the coast. Related to this is the percentage of mesophyll cells contiguous with the epidermis. Palisade cells show an increase from 86% to 99.7% from population A to E whereas spongy mesophyll increases more markedly from 56% to 84%.

The number of tiers in the palisade tissue increases from two in the fronds of population A to four or more in population E, and the average thickness of the tissue increases from  $37\ \mu$  to  $120\ \mu$  (figs. 3-7). The spongy mesophyll increases in average thickness from  $46\ \mu$  in population A to  $107\ \mu$  at C. However, in contrast to palisade mesophyll the spongy tissue decreases in depth to  $79\ \mu$  in the most xeric population.

Stomatal size remains relatively constant in all populations. The smallest occur in population E. Number of stomata per  $\text{mm}^2$ , however, varies considerably with a decrease from 33 to 16 in populations A to D and a sharp increase in E to 55. The number of trichomes per  $\text{mm}^2$  shows a corresponding decrease in number to population D with a sharp increase at E.

DISCUSSION AND CONCLUSIONS. The populations examined in this paper were chosen for their location in relation to the coast. Habitat characteristics of each relate to the topography of Pt. Reyes, which has a central spine of mountains sloping to low plains at the bluffs above the ocean. Anatomical data can be correlated with these habitats. The basic environmental factors influencing frond histology of the populations studied are probably sunlight and wind exposure. The effect of salt-spray on population E is more pronounced than at the other stations and may help explain the anomalies of increased density of stomata

FIG. 2. Composition of the four tissues of the blade; clear = adaxial epidermis; stippled = palisade layer; solid = spongy layer; clear (lower) = abaxial epidermis; abscissa = population; ordinate = number of  $\mu$  in  $20\ \mu$  separations.

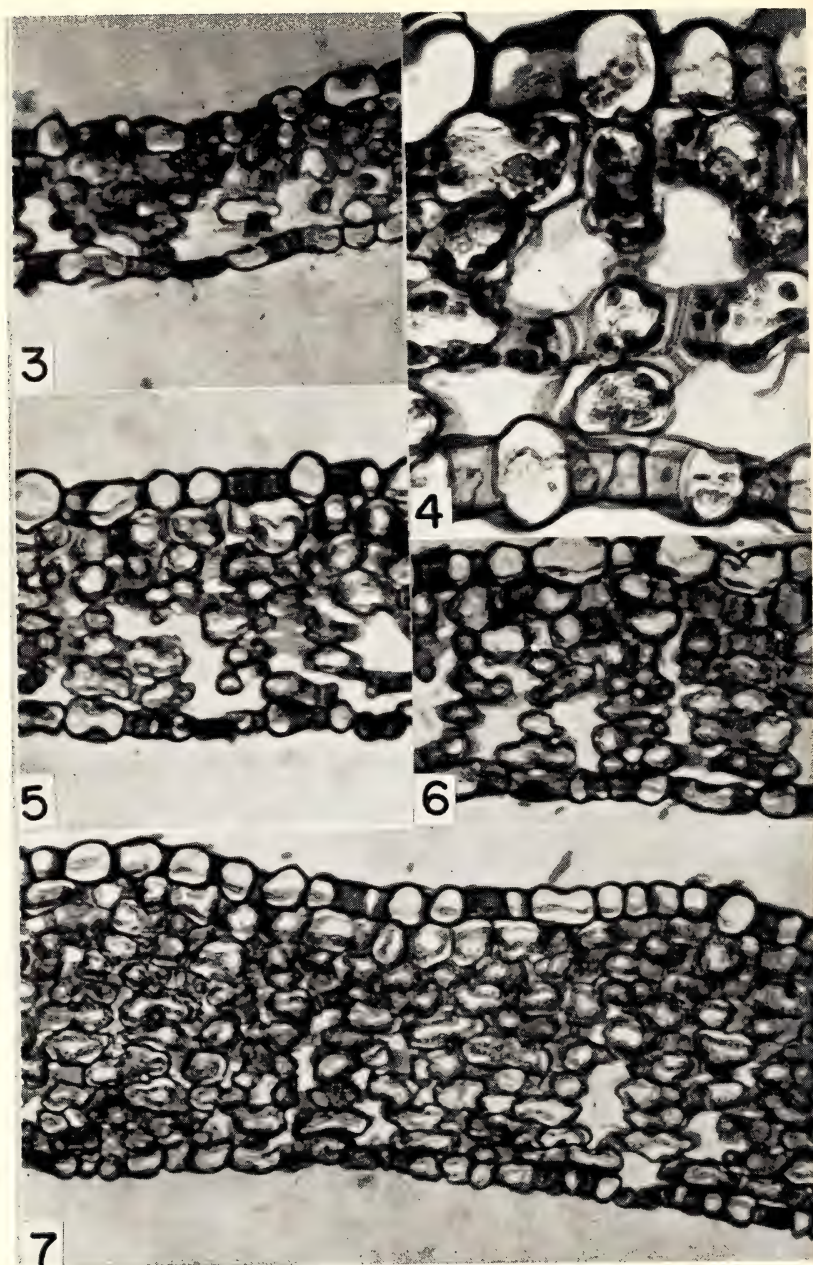
TABLE 1. AVERAGE SIZE AND RANGE OF FROND TISSUES

Character	Population				
	A	B	C	D	E
Blade length (mm)	258.7	134.0	144.2	119.3	142.6
Blade thickness ( $\mu$ ) range	128.0	192.0	240.0	256.0	260.0
	105-175	145-240	187-318	188-335	190-320
Per cent composition tissues:					
Epidermis, adaxial	20	19	16	15	13
Palisade mesophyll	30	32	30	37	47
Spongy mesophyll	36	37	42	38	30
Epidermis, abaxial	14	12	12	10	10
Tissue thickness ( $\mu$ )					
Palisade mesophyll	37	64	71	95	120
range	22-55	(32)45-83(125)	50-100	(55)65-125	(70)110-140(175)
	46	73	107	97	79
Spongy mesophyll	30-75	(30)55-100	65-145(170)	(30)50-132(175)	(35)60-110
Contiguosness with epidermis:					
Palisade (%)	86.0	99.4	97.5	99.7	99.7
Spongy (%)	56.0	74.0	67.0	79.0	84.0
No. trichomes/mm <sup>2</sup>	4	1	0.9	0.75	2.77
No. stomata/mm <sup>2</sup> range	33	30	16	16	55.25
	24-46	24-36	10-22	(8)12-24	46-62
Stomatal length ( $\mu$ )	51	67	58	66	51
range	49-60	60-75	45-70	(50)60-75	45-60
Stomatal width ( $\mu$ )	39	47	46	43	33
range	35-45	42-51	40-52	40-50	25-40
No. fronds examined	31	17	18	29	19



TABLE 2. AVERAGE CELL SIZE AND RANGE WITHIN EACH FROND TISSUE

Tissue	Population				
	A	B	C	D	E
<b>Epidermis:</b>					
adaxial: depth ( $\mu$ )	26	37	37	41	44
range	17-35	20-52	25-50	23-55	25-55
diameter ( $\mu$ )	44	51	54	71	58
range	(14) 35-90	(20) 32-80(105)	(20) 32-120	23-120	20-100
abaxial: depth ( $\mu$ )	20	24	28	25	27
range	11-35	17-37	20-40(65)	15-35	20-40
diameter ( $\mu$ )	33	44	47	59	56
range	(15) 25-60	20-70	20-85(110)	25-95(122)	20-95(120)
<b>Palisade:</b>					
depth ( $\mu$ )	25	38	32	41	32
range	17-40(50)	20-47	23-50	22-75	15-50(60)
diameter ( $\mu$ )	31	39	50	58	51
range	13-55(70)	20-50(65)	25-75(125)	33-95	(18) 30-95
no. tiers	2.0	2.4	2.5	3.2	4.4
range	1-3	1-3	1-3	2-4	3-7
air space (%)	6.6	0.6	2.5	0.5	0.3
<b>Spongy:</b>					
depth ( $\mu$ )	20	32	28	33	28
range	15-33	24-42	20-45	20-47	15-40(50)
diameter ( $\mu$ )	40	55	55	67	66
range	(19) 30-65	(33) 40-80	20-85(105)	30-90(175)	20-100(115)
air space (%)	45	26	33	21	16



FIGS. 3-7. Transverse section of frond pinnae from populations A to E at Pt. Reyes; 3. Pop. A; 4. Pop. B; 5. Pop. C; 6. Pop. D; 7. Pop. E. Figs. 3, 5-7  $\times 150$ ; fig. 4  $\times 450$ .

and trichomes in that population. However, in the latter case there were more trichomes in population A than E.

In other parts of the range of *P. californicum* plants with herbaceous to semi-coriaceous fronds can be found growing in shaded forests directly above the ocean. Coriaceous fronds have also been found on plants in exposed situations completely removed from coastal influences. Fronds from these latter areas, however, do not reach the extremes in morphology demonstrated by Pt. Reyes plants.

Population A grows in the most mesic environment of all those studied here, a fact clearly reflected in the relatively thin fronds which have thick spongy mesophyll and numerous air spaces. Habitats of populations B and C were open on the north and had less canopy cover. Although they appeared somewhat similar in exposure frond thickness of plants from population C differs from that of B almost to the same extent as B does from A. Contrastingly, differences between plants of C, D, and E are less extreme with a gradual increase in thickness toward the latter. Fronds of population E are more than twice as thick as those of A, a difference attributable to the palisade mesophyll.

Angiosperms may exhibit elongation of palisade cells (Clements, 1905) but this does not seem to be the case in *Polypodium* where the isodiametric cells only become larger. However, in both an increasing amount of palisade tissue forms at the expense of air space and spongy mesophyll. Although individual cells become larger in *Polypodium* with relation to more xeric habitats the increase of tissue thickness results from an increase in cell and tier number. This parallels the situation in *Rumex acetosella* (Transeau, 1904) which exhibits one cell layer of palisade mesophyll in mesic habitats and 2 to 3 layers in xeric environments.

The increase in stomata number in angiosperms inhabiting xeric environments has been noted by Salisbury (1927) and Philpott (1956). This increase in number is usually attributed to spacing and change of epidermal size. It has also been shown that numerous stomata usually have a higher transpiration rate. The sudden increase in stomata from population D to E indicates a drastic change in environment, perhaps regulated by the concentration of salt-spray in the atmosphere. Kunkel (1961) reported larger stomata in fronds of *P. lasiopus* from shaded areas, smaller ones in plants of sunny areas. In addition, fronds more exposed to sun were much more fleshy and approached xerotypes in succulence. He stated that all possible transitional forms may be encountered in individual habitats and feels that both of the forms (shaded and sunny) could be described as ecotypes. Transplant experiments with *P. californicum* have shown that in some instances the coriaceous character of fronds is genetically controlled.

It is evident at Pt. Reyes that there is a clinal gradient in frond structure correlated with increased exposure to sun and wind. Generally, the trends which were discovered may be summarized as follows:

1. There is a direct relationship between frond thickness and degree of habitat modification from mesic to xeric environments.
2. This thickness is due mainly to a greater size of the palisade tissue although corresponding increases accompanied it in other tissues.
3. Individual cell sizes within each tissue was greatest in population D, somewhat smaller in E. The feature responsible for the greater thickness of fronds in the latter was the additional tiers in the palisade mesophyll.
4. Stoma number gradually decreases from mesic to more xeric habitats but sharply increases at the coast.

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## THE CALIFORNIA SPECIES OF GUTIERREZIA (COMPOSITAE-ASTEREAE)

OTTO T. SOLBRIG

The genus *Gutierrezia* (Compositae-Astereae) is represented in California by four species: *G. californica* Douglas, *G. bracteata* Abrams, *G. sarothrae* (Pursh) Britt. & Rusby, and *G. microcephala* (DC.) T. & G. (Solbrig, 1960). Of these four species, *G. microcephala* is fairly distinct and has been recognized in all the major floristic treatments. The other three species are closely related and their limits and identities have been considered differently in each of the major floristic treatments of California (Jepson, 1925; Abrams and Ferris, 1960; Munz, 1959). Since the characters distinguishing *G. bracteata* from *G. sarothrae* are not recognized easily in herbarium specimens and since there has been some doubt expressed in the past (Munz, 1935) as to the validity of these species, it was believed necessary to pursue the matter further by means of intensive field studies and population analyses. This report is an account of the results.

I am grateful to the Evolutionary Biology Program of Harvard University for assistance in field studies and to the National Science Foundation for a research grant. I also wish to acknowledge Miss Karen Niecke for laboratory assistance and Peter H. Raven for seeds. Lorin I. Nevling, Jr. kindly has read the manuscript and made valuable editorial suggestions. I am also very grateful to G. L. Stebbins for a stimulating discussion on this subject.

### MATERIALS AND METHODS

This study is based on statistical analyses of wild populations, chromosome counts, garden investigations, hybridization experiments and herbarium specimens. Up to nine characters (height of plant, length and width of the involucre, number of ligulate and tubular flowers, length and width of achenes, length of pappus and pollen diameter) were measured in 50 plants chosen at random in each population studied. In this way, the value of different taxonomic characters could be evaluated in detail. Twenty populations were analyzed: two of *G. microcephala*, three each of *G. sarothrae* and *G. californica* and 12 of *G. bracteata*. Chromosome numbers were determined in a total of 25 populations. Two hundred pollen grains were measured in 16 populations of known chromosome number. Several collections were grown under uniform conditions at the Experimental Gardens of the University of California Botanical Gardens in Berkeley and later at the Harvard University Greenhouses in Cambridge, Massachusetts.

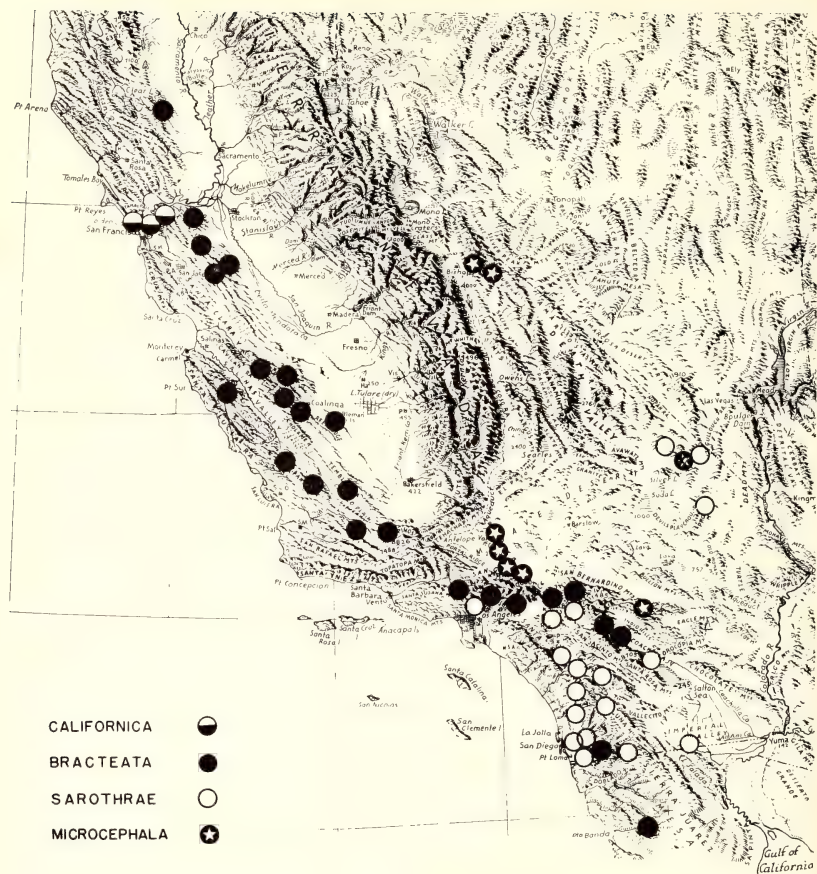


FIG. 1. Distribution of populations of *Gutierrezia* in California. (Base map Copyrighted by Ginn & Co., used by permission.)

## RESULTS

*Distribution and ecological conditions.* The most xerophytic of the California species of the genus is *G. microcephala*. It grows on the fringes of the Colorado and Mohave deserts on dry mountain slopes and in the valleys, but not in true desert areas (fig. 1). The more mesophytic *G. bracteata* and *G. sarothrae* have similar requirements. Both species are found in dry washes, rocky slopes and also occasionally in roadside ditches and in fields. *Gutierrezia bracteata* grows from Yolo Co. south along the drier parts of the Coast Ranges to northern Baja California; *G. sarothrae* is found only south of the Tehachapi Mts. all the way to southern Baja California, Cedros I. and west into the Great Basin and northern Mexico. *Gutierrezia californica* on the other hand is a species with narrow ecological requirements. It is found only on three serpentine

outcrops in San Francisco Bay: one population on the Oakland Hills, one population on Angel Island, and one population on Point Bonita, Marin Co. Each of these three populations consists of less than 500 plants and all of them, but particularly the ones in Oakland and Marin Co., are threatened by encroaching civilization. Although *G. californica* is found in nature only on serpentine, it can be grown on non-serpentine soil without adverse effects. The same is true for progeny of the populations of *G. bracteata* which grow on serpentine soil.

*Morphological analysis.* a. Habit. The four species are similar in habit. All four are slightly woody subshrubs, semi- or completely globose, with small leaves and medium to small inflorescences borne at the end of the branches. *Gutierrezia californica*, which is significantly smaller than the rest, also conforms less to the habit description given, having a tendency to form only a few undivided and spreading branches which give rise to a rather open shrub. It also produces fewer inflorescences which tend to be borne solitary or on long stalks at the end of the branches. The other species form rather tight globose shrubs which are covered in the fall by small yellow heads which offer a rather showy display. *Gutierrezia bracteata* is probably the largest species, but the differences are not significant (table 1). When grown in the experimental garden, all four species maintained their characteristics but increased in size.

b. Inflorescence. It already has been stated that the capitula of *G. californica* are borne solitary or in loose groupings at the end of the branches. Those of *G. microcephala*, on the contrary, are found in tight glomerules of 3 to 8 sessile inflorescences. The disposition of the heads of *G. sarothrae* is similar to that of *G. microcephala* but there is often a short pedicel to each inflorescence while in *G. bracteata* as a rule the heads are borne on pedicels several millimeters long. There is, nevertheless, quite a bit of variability in this character.

There are differences in addition in the size of the capitula (table 1). The widest capitula are those of *G. californica* which vary from a population mean of 3.6 mm–4.20 mm; the narrowest are those of *G. microcephala* which average less than 1 mm wide. The capitula of *G. sarothrae* vary from an average value of 1.5 mm–2.5 mm per population while those of *G. bracteata* vary from 2.0 mm–3.4 mm. Although there is a slight overlap, it is clear that this last species tends to have wider heads. *Gutierrezia californica* also has the highest involucre (mean 5.70–7.50 mm average per population), but there is a sizable overlap with *G. bracteata* (mean 5.1–6.4 mm). *Gutierrezia sarothrae* (mean 3.4–4.4 mm) and *G. microcephala* (mean less than 3 mm) have shorter heads.

Populations of these four species can be separated on the basis of mean population values of these two capitulum parameters (figs. 2, 3). Not so individual heads which can deviate up to two times from the mean population size. Nevertheless, if an effort is made to sample average plants and to measure several heads, the capitulum furnishes one of the most valuable diagnostic characters.





c. Flowers. Two floral characters are of taxonomic significance: number of flowers per inflorescence and size of pappus, both for the ligulate and tubular flowers.

The largest number of flowers per capitulum is found in *G. californica*. The mean values per population are 7.2–7.5 ligulate flowers and 10.2–12.5 tubular flowers per capitulum. *Gutierrezia bracteata* follows with 4.9–7.6 ligulate and 4.3–9.0 tubular flowers; *G. sarothrae* has 5.5–5.8 ligulate and 4.6–5.9 tubular ones; while *G. microcephala* has almost consistently one ligulate and one tubular flower per head. As with the characteristics of the capitulum, *G. californica* and *G. microcephala* are fairly distinct, while *G. bracteata* and *G. sarothrae*, although differing, have an area of overlap (fig. 2). Also it has to be remembered that these are mean values. Individual heads may have an excess or deficiency of the numbers given and at least 10 capitula should be analyzed in order to obtain a fairly reliable value.

The pappus length follows the same pattern as the number of flowers in a head: *G. californica* has the largest pappus, *G. microcephala* the smallest; *G. bracteata* and *G. sarothrae* have similar values, although the figures for the former are slightly larger. The pappus furnishes a valuable additional character.

d. Pollen size. The pollen diameter of populations of *G. sarothrae*, *G. bracteata* and *G. californica* of known chromosome number was measured. The results are represented graphically in Fig. 2. Although there is a correlation between chromosome number and pollen diameter, the distribution is a continuous one. The variability exhibited by *G. bracteata* in this character is worth noting.

*Chromosome number.* The California populations of *Gutierrezia* counted to date are listed in Table 2. All populations of *G. sarothrae* had  $n = 4$ , those of *G. microcephala*  $n = 8$  and those of *G. californica*  $n = 12$ . So far only one number has been found in each population, but not more than five plants have been sampled per population. All the populations of *G. bracteata* with  $n = 12$  are found on the south Coast Ranges while populations with  $n = 8$  are found throughout the range of the species. No obvious morphological difference could be found in the chromosomes of the various species (Rüdenberg and Solbrig, 1963).

*Hybridization attempts.* Plants of *G. sarothrae*, *G. californica* and *G. bracteata* ( $n = 8$  and  $= 12$ ) were intercrossed in Berkeley in 1957 and 1958 (Solbrig, 1960) and again in Cambridge in 1960 and 1961. All these attempts except one were unsuccessful. An interspecific hybrid was obtained between *G. californica* and *G. bracteata* ( $n = 8$ ), but was completely sterile (loc. cit.). Although normally outbreeding, the plants of *Gutierrezia* are self-compatible; this hinders artificial hybridization attempts considerably. The results therefore are not as conclusive as could be wished, but apparently the species are fairly intersterile. In view of the differences in chromosome number this result is not surprising.

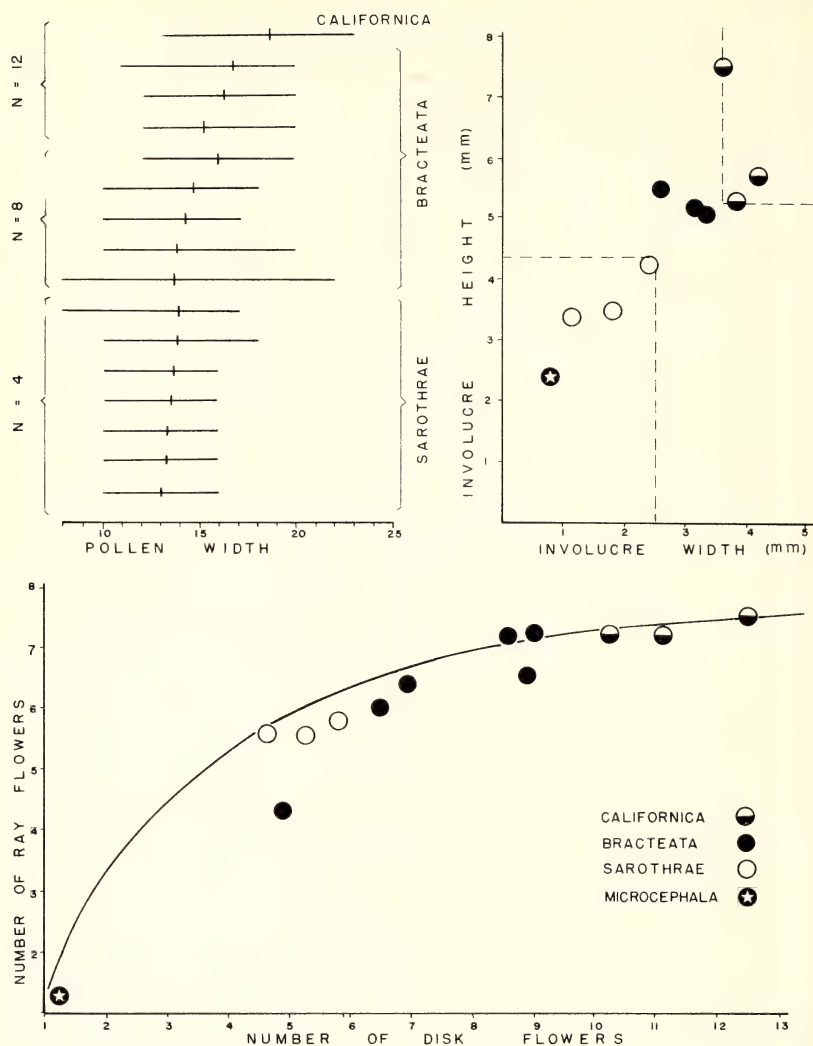


FIG. 2. Graphs showing correlation of pollen diameter (in micra) and chromosome number (horizontal bar = range; vertical bar = mean); mean population width and height of the involucre (in mm); and mean number of disk and ligulate flowers in a head.

## DISCUSSION

*The taxonomic problem.* Viewed from the vantage point of good knowledge of the species in the field and after carefully analyzing a number of breeding populations, the species appear fairly distinct. The same cannot be said, unfortunately, when the problem at hand is the

TABLE 2. CHROMOSOME NUMBERS IN CALIFORNIA SPECIES OF GUTIERREZIA

*G. californica*.  $n = 12$ . Contra Costa Co., Oakland Hills, Solbrig 2154. Marin Co., Angel Island, Solbrig 2681; Point Bonita, Solbrig 3431.

*G. bracteata*.  $n = 8$ . Yolo Co., Cache Creek, Rancho S. Ana Bot. Garden seed. Alameda Co., Corral Hollow, Solbrig 2159. Stanislaus Co., Patterson, Solbrig 2743, 3433. San Benito Co., Los Gatos Canyon, Solbrig 3436. San Luis Obispo Co., La Panza, Solbrig 2751. Los Angeles Co., Tujunga, Wash., Solbrig 3440.  $n = 12$ . San Luis Obispo Co., Temblor Range, Solbrig 2753. Santa Barbara Co., Padres Nat. Forest, Solbrig 2167; Cuyama Valley, Solbrig 2166, 3439. Riverside Co., Idylwild, Solbrig 2774. San Benito Co., New Idria, Solbrig 2830. San Bernardino Co., Tahquitz Canyon, Solbrig 2775.

*G. sarothrae*.  $n = 4$ . Riverside Co., Idylwild, Solbrig 2773. San Diego Co., Aguanga, Solbrig 2760; Temecula, Solbrig 2758; Santa Ysabel, Solbrig 2763, 2765; Rancho Santa Fe, Solbrig 2769; Chula Vista, Solbrig 2766, 2768.

*G. microcephala*.  $n = 8$ . Inyo Co., White Mts., Rancho S. Ana Bot. Garden seed 9389. San Bernardino Co., Morongo, Rancho S. Ana Bot. Garden seed 8382.

identification of herbarium specimens, particularly incomplete or "scrappy" ones with poor or no label annotations. *Gutierrezia californica* and *G. microcephala* can be separated easily on the basis of involucre size and number of flowers per capitulum. On the other hand, large specimens of *G. sarothrae* and small ones of *G. bracteata* are likely to be confused. The characters used here offer the highest probability of correct identification, but the only absolute character is the chromosome number which obviously cannot be obtained from a herbarium specimen. A key to identify the California species of *Gutierrezia* follows.

KEY TO CALIFORNIA SPECIES OF GUTIERREZIA

- Involucre 3.5 mm wide or more; tubular flowers more than 10; ligulate flowers more than 7. Plants of the San Francisco Bay area.....1. *G. californica*
- Involucre less than 3.5 mm wide; tubular flowers less than 9; ligulate flowers less than 7.
  - Involucre 1.5 mm wide or less; 2.5 mm high or shorter; ligulate flower 1; tubular flower 1. Plants of the fringes of the Mohave and Colorado deserts and the White Mts.....2. *G. microcephala*
  - Involucre 1.5 mm wide or more; 3.0 mm high or more; ligulate flowers more than 4; tubular flowers 3 or more.
    - Involucre 2-3.5 wide; 5-7 mm high; ligulate flowers 5-7; tubular ones 4-9. Plants of the Coast Ranges and southern California.....3. *G. bracteata*
    - Involucre 1.5-2.5 mm wide; 3.5-4.5 mm high; ligulate flowers 4-6; tubular one 3-6. Plants of southern California.....4. *G. sarothrae*

A second taxonomic question is if populations of *G. bracteata* with  $n = 8$  and  $n = 12$  merit recognition as distinct taxa. The morphological analysis does not show any appreciable difference but the crossing attempts seem to indicate that they are intersterile as expected. The situation of *G. bracteata* is not unique in the genus; polyploid populations of *G. sarothrae* (Solbrig 1960; 1964) and of *G. microcephala* (Solbrig, 1960) are also known. Even though there might be some merit in giving taxonomic recognition to these genetically isolated populations

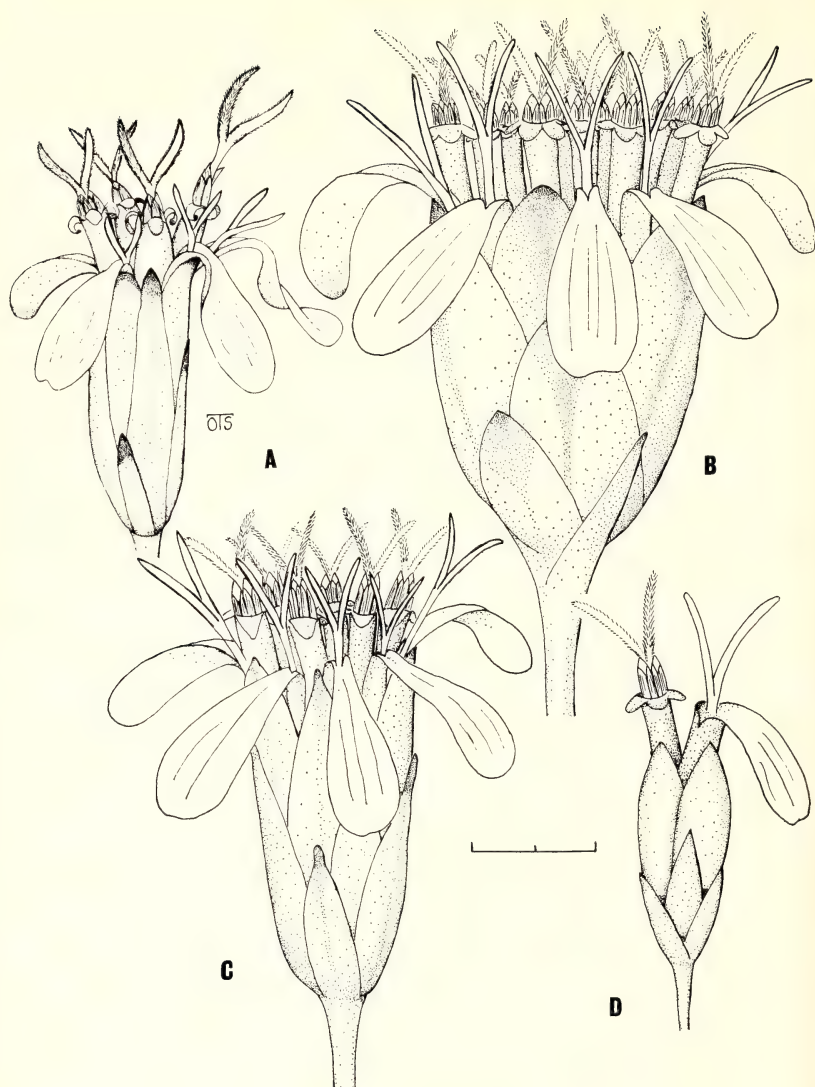


FIG. 3. Capitula of the four species of *Gutierrezia*: A, *G. sarothrae*; B, *G. californica*; C, *G. bracteata*; and D, *G. microcephala*.

(in reality sibling species), I prefer not to. In the absence of any absolute morphological difference (no matter how small), it serves, in my opinion, no practical purpose.

*Evolutionary history.* Any statement about the evolutionary history of these species is highly speculative since there is no direct paleobotanical evidence. Nevertheless this much seems clear. The genus *Gutierrezia*



represents a polyploid complex with a base number of  $x = 4$  and speciation has taken place by increases in chromosome number together with ecological specialization. Of the living species, *G. sarothrae* is the most primitive one and is probably not much different from the ancestral stock (Solbrig, 1964, and in prep.), which was probably native to the lower central basin or to northern Mexico. It is clear from the morphological analysis and geographic distribution that there were at least two invasions of *Gutierrezia* into California. One was by *G. sarothrae* and the other by *G. microcephala*. This latter species is probably of more recent arrival, both on account of its highly specialized type and also because it occupies a habitat which is relatively recent in California (Axelrod, 1950; 1956). The range of *G. sarothrae* might have once been continuous between the central basin and its present California distribution, continuity which was interrupted by the formation of the Mohave and Colorado deserts in late Pliocene age. The presence of isolated populations of *G. sarothrae* in the New York Mts. seems to indicate so. The species might have also extended once north along the coast ranges, although I have no indication of this. But it is tempting to speculate that this hypothetical continuous range was broken by the invasion of the sea into the Cuyama and Central Valley in the late Miocene and early Pliocene (Axelrod, 1956; James, 1963). The isolated populations to the north could have then evolved into  $n = 8$  *G. bracteata*. Secondary contact after the retreat of the water in late Pliocene or Pleistocene might have produced  $n = 12$  *G. bracteata* through amphiploidy. The tetraploid populations of *G. bracteata* might be the result of autopolyploidy followed by selection in the manner postulated by Darlington (1956), or they may be the result of amphiploidy with a now extinct species. This last pattern would be more in accordance with what is observed in other polyploid complexes (Stebbins 1950; and pers. comm.), nevertheless the close morphological similarity between *G. sarothrae* and *G. bracteata* does not rule out the first explanation.

The origin of *G. californica* is equally obscure, but it probably diverged from *G. bracteata*, by rapid evolution after moving into the slightly more humid climate of the San Francisco Bay area. If the evolution of *G. californica* was the result of isolation or of hybridization of a tetraploid *G. bracteata* with an extinct diploid species cannot be determined. Nevertheless, the absence of known hexaploid *G. bracteata* north of San Benito Co., the morphological distinctness of *G. californica* and the pattern of behavior of other polyploid complexes appear to favor the hybridization hypotheses.

A point worth mentioning is the adaptation of populations of *G. bracteata* and *G. californica* to serpentine soils. The first of these species is not quite a true serpentine species. In every instance, the populations are found on soil fairly mixed with materials derived from other types of rocks. This can be observed best in the large serpentine outcrops in New Idria.

On the other hand *G. californica* is a true serpentine endemic. Kruckeberg (1954) has discussed some genetic aspects of serpentine adaptation in particular reference to the genus *Streptanthus*. *Gutierrezia californica* can be grown on regular soils, but apparently cannot withstand competition in such soils in a natural situation. Plants of *G. bracteata* from non-serpentine localities can grow on serpentine, but they do better on other soils. They can, nevertheless, be considered preadapted to serpentine. In the San Francisco Bay area, the only suitable habitats available for *G. bracteata* plants were probably the serpentine outcrops. After that, isolation together with selection and genetic drift can be accounted to have brought forth a faster rate of evolution.

Gray Herbarium, Harvard University

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TAXONOMY OF POLYGONUM, SECTION POLYGONUM  
(AVICULARIA) IN NORTH AMERICA

THOMAS R. MERTENS AND PETER H. RAVEN

The limits of *Polygonum* sect. *Polygonum* (*Avicularia*) have been defined by Hedberg (1946) in an illuminating study of pollen morphology in *Polygonum* and related genera. Excluded are most of the native species of North America, now regarded as belonging to *Polygonum* sect. *Duravia*. Within sect. *Polygonum*, however, there has been little agreement as to specific limits in North America (Fernald, 1950; Gleason, 1952; Löve and Löve, 1956) or elsewhere.

Styles' (1962) excellent biosystematic treatment of this group in the British Isles appeared to offer some orientation for the possible resolution of its complexities in North America. We have addressed ourselves specifically to two problems: 1. The identity of certain populations found in Marin Co., California, and heretofore referred to *P. fowleri* Robins. (Howell, 1949); and 2. The resolution of the complex referred to *P. aviculare* L. in North America, especially in the western United States. The solution of these problems has demanded a consideration of all species of the group in North America, and certain critical observations made during the course of this work will be reported here. Thus the present paper is a preliminary survey of the North American species<sup>1</sup>.

Four species of *Polygonum* sect. *Polygonum* found in North America have inflorescences that appear terminal, the flowers being more or less clustered at the summits of the stems among very reduced leaves or bracts. *Polygonum tenue* Michx., morphologically similar to this group, has pollen of the *Duravia*-type, and is presumably referable to that section. The four species that do belong to sect. *Polygonum*, occur in North America, and appear to have terminal inflorescences are *P. arenarium* Waldst. & Kit., *P. argyrocoleon* Steud. ex Kunth, *P. patulum* Bieb. (*P. bellardii* auct., non All.) and *P. ramosissimum* Michx. The first three of these species are introduced from Eurasia, the last a native of North America. We concur with Gleason (1952) in considering *P. exsertum* Small (type, US!) a synonym of *P. ramosissimum*. In this species, as in some of those that will be discussed below, enlarged, olivaceous achenes are sometimes formed, particularly late in the season (Styles, 1962). Such fruits are usually flattened and wrinkled but perfectly viable. They are very different in form from the normal fruits borne by the same plant. In this species, normal fruits are mostly 2.75–3.25 mm long and 1.75–2 mm wide, whereas late-season fruits are

<sup>1</sup> This study was carried out at Stanford University while the senior author held National Science Foundation Faculty Fellowship 63115. The authors are most grateful to B. T. Styles and to J. T. Howell for their suggestions concerning this paper.

3.75–5.4 mm long and 1.5–2.4 mm wide. Plants that have been referred to *P. exsertum* have a high proportion of distended fruits. We are unable to account for the report by Löve and Löve (1956) of  $2n = 20$  in *P. ramosissimum* and  $2n = 60$  in *P. exsertum* and suggest that chromosome counts be made of a wide range of material before these numbers be associated with morphologically defined entities. Some of the material named *P. exsertum* in herbaria is not *P. ramosissimum* but rather the analogous late-season form of *P. prolificum* (Small) Robins., a species discussed below.

The remaining North American species of sect. *Polygonum*, in which the flowers are scattered along the stem, may be separated by the following key.

Achenes shining.

Fresh foliage conspicuously glaucous; ocreae of lower nodes very conspicuous, 7–10 mm long; Atlantic coast.....1. *P. glaucum*

Fresh foliage not conspicuously glaucous; ocreae less than 8 mm long, not conspicuous.

Fruits subultrous; undistended fruits about 2 mm long.....2. *P. prolificum*

Fruits glossy; undistended fruits 2.8–4.7 mm long.

Undistended fruits 4–4.7 mm long; distended fruits to 5.75 mm long.

3. *P. oxyspermum*

Undistended fruits 2.8–3.4 mm long; distended fruits to 4.6 (–5) mm long.

4. *P. marinense*

Achenes dull.

Perianth bottle-shaped, constricted just below the apex; leaves blunt, oblong; achenes about 3 mm long.....5. *P. erectum*

Perianth not constricted below the apex.

Achenes abruptly beaked, granular.....6. *P. fowleri*

Achenes not abruptly beaked, not notably granular.

Branch leaves much smaller than the stem leaves; fruiting perianth divided nearly to the base; fruit with 3 equal concave sides.

Stem leaves sessile or with petioles included in the ocreae; fruits 2.5–3.5 long.....7. *P. aviculare* s. str.

Stem leaves with petioles 4–8 mm long projecting from the ocreae; fruits 3.5–4.5 mm long.....9. *P. boreale*

Branch leaves and stem leaves subequal; fruiting perianth divided about half its length; fruit with 2 convex and one shorter concave side.

8. *P. arenastrum*

1. *P. glaucum* Nutt. A very distinctive species of the sands of the Atlantic Coast from Massachusetts to Georgia, with very large ocreae, *P. glaucum* has occasionally been recorded as the west Eurasian and North African *P. maritimum* L., which is a perennial and differs in several other characters. It has not been confused with other species in this treatment. Löve and Löve (1956) have reported  $2n = 40$  in *P. glaucum*.

2. *P. prolificum* (Small) Robins. This species has sometimes been confused with *P. ramosissimum*, but can be distinguished by its short pedicels (included within, rather than exserted from, the ocreae) and less shiny fruits. Its flowers are not markedly clustered at the apex of



the stems. It is widespread across the United States and southern Canada, but commoner in the central and eastern portions of the continent. It can be reported, probably for the first time, from California, on the basis of the following collection: Cuttings Wharf on Napa River, Napa Co., 8 Oct. 1932, *Howell 10800* (CAS). At this locality, and over much of the remainder of its range, it is doubtless introduced; but it is known only from North America and must therefore be native there.

3. *P. oxyspermum* Meyer & Bunge ex Ledeb. In North America this species occurs in a very small area in eastern Canada (Newfoundland, New Brunswick, and Nova Scotia). It is widely distributed on the coasts of northwestern Europe and may be introduced in North America, as suggested by Hultén (1963) for a number of species with similar distribution patterns. Styles (1962) pointed out that the differences between *P. oxyspermum* and *P. raii* Babington were not constant, and reported a chromosome number of  $2n = 40$  for representatives of both entities from Europe. Later, Webb and Chater (1963; 1964) considered *P. raii* a subspecies of *P. oxyspermum*, making the combination *P. oxyspermum* ssp. *raii* (Babington) Webb and Chater (1963). Styles described the fruits of *P. raii* as being 5–6 mm long and 3–3.5 mm wide, but his illustration (Styles, 1962, pl. 9) shows them as ranging from 4–5 mm in length and from 2.4–3.2 mm in width. On the other hand, his illustration of *P. oxyspermum* shows enlarged fruits that are apparently comparable to the late season fruits of *P. ramosissimum* discussed above. These fruits are 5–6.1 mm long, and paler than the normal ones. Webb and Chater (1964) consider *P. oxyspermum* ssp. *oxyspermum* to have fruits 5–6.5 mm long, and ssp. *raii* fruits 2.5–5.5 mm long. Thus the differences between the two subspecies may depend on the proportion with which they produce distended fruits late in the season (or earlier?). In the small amount of European material named *P. raii* that we have examined, the fruits are mostly 4.5–5 mm long. North American specimens we examined had normal fruits 4–4.7 mm long and 2.5–3.2 mm wide, and occasionally abnormal ones (as in the collection that is the type of *P. acadiense* Fernald) to 5.75 mm long. Thus they seem to fall in the same range of the European material. We have determined a very large series of this species (DAO, GH, NMC, US) as *P. oxyspermum*, since subspecific lines in the European material may or may not be applicable in North America. Löve and Löve's counts of  $2n = 80$  (perhaps from a cell with doubled chromosome number?) in *P. oxyspermum* and  $2n = 60$  in *P. raii*, both from North American material, need to be confirmed.

4. *P. marinense* Mertens & Raven, sp. nov. A *P. oxyspermo* differt: acheniis minoribus, 2.8–3.4 mm longis, 1.9–2.3 mm latis, interdum ad 4.6 (–5) mm longis, 2.5 mm latis, refertis, subplanis, subrugosis; sepalis ex comparatione angustiore hyalinomarginatis; pedicellis filiformis, 2–5.5 mm longis, floribus fructibusque saepe longe ab ocreis exsertis; chromosomata  $2n = 60$ .

Type: Marin Co., Calif., common in salt marshes at the head of Drake's Estero, Point Reyes Peninsula, 22 Aug. 1961, *Raven 16568* (DS). Growing up among mats of *Salicornia virginica* and *Distichlis spicata*.

Additional specimens examined: California. Marin Co.: salt marshes, Burdell, *Howell 21282* (CAS, DS); Escalle salt marsh, *Howell 19396* (CAS); salt marsh, Inverness, *Howell*, 1945 (CAS); saline marsh, north of Inverness, *Nobs & Smith 912* (CAS, DS); salt marsh at head of Drake's Estero, *Howell 25326* (CAS).

This distinctive new species is entirely different from *P. fowleri*, with which it has been confused, but very similar to *P. oxyspermum*. It differs from the latter in its smaller fruits, normally 2.8–3.4 mm long, and even when distended only up to 4.6 (–5) mm long; its longer, more slender pedicels in fruit; its more narrowly margined sepals; and its less conspicuous ocreae. In addition, its chromosome number is  $2n = 60$  (progeny of the type collection), not  $2n = 40$ .

*Polygonum robertii* Lois. is a name that has been associated with a similar group of plants found on the shores of the western Mediterranean. These plants are said often to be perennial and to have shining achenes 2–3 mm long. Styles (1962) excluded them from his concept of *P. raii*, but Webb and Chater (1964) include them in their concept of *P. oxyspermum* ssp. *raii*. Consequently, Webb and Chater considered this taxon to have achenes 2.5–5.5 mm long. Whether these Mediterranean plants are in fact conspecific with *P. oxyspermum* or with *P. marinense* (geographically there is more in favor of the latter hypothesis than the former), there is considerable doubt about the correct application of the name *P. robertii* Lois. (Styles, 1962; Webb and Chater, 1964). *Polygonum marinense* is certainly not conspecific with *P. oxyspermum*, and even if it is found to include the plants of the western Mediterranean, there is apparently no earlier, valid, certain name for these. The native status of *P. marinense* in North America must for the present remain doubtful.

5. *P. erectum* L. This very distinctive species, which occurs from the region of the Rocky Mountains east to the Atlantic seaboard, should not be confused with the taxon called *P. aviculare* L. var. *erectum* (Roth) Koch, which is generally considered a synonym of *P. aviculare* s. str. Löve and Löve (1956) reported a somatic chromosome number of  $2n = 40$  for this species and  $2n = 20$  for *P. achoreum* Blake, but as we are unable to find any character to distinguish these two entities satisfactorily, we believe that it would be desirable to reinvestigate this complex cytologically.

6. *P. fowleri* Robins. This species ranges from Maine north to Newfoundland, across the continent to Alaska, and south at least to the vicinity of Puget Sound, Washington. It is perhaps the most distinctive entity in the entire group. Its achenes are 2.75–3.5 mm long and 1.75–2.25 mm wide. Enlarged late season achenes are relatively rare, and are up to 4.25 mm long and 2.25 mm wide. A high incidence of biconvex fruits is also characteristic. Plants from Marin Co., California, hitherto referred to this species (Howell, 1949; Munz, 1959) are totally different

and have been described above as *P. marinense*. We have examined the type of *P. fowleri* (GH) and a large series of specimens from throughout its range. We have also examined the type of *P. allocarpum* Blake (US) and a series of specimens referred to that species. Like Gleason (1952) we are unable to distinguish this entity consistently from *P. fowleri*, and are thus unable to account for the somatic chromosome numbers  $2n = 40$  for *P. fowleri* and  $2n = 60$  for *P. allocarpum* that have been reported by Löve and Löve (1956).

7. *P. aviculare* L. s. str. and 8. *P. arenastrum* Jord. ex Bor. With *P. boreale* (no. 9), these species constitute the North American members of the *Polygonum aviculare* complex. They are characterized by their dull, striate fruits and flowers in axillary fascicles. Styles (1962) divided this complex in Britain into 4 species: *P. arenastrum* Jord. ex Bor., *P. aviculare* L. s. str., *P. boreale* (Lange) Small, and *P. rurivagum* Jord. ex Bor. The last-mentioned entity is not known from North America, the plants described by Löve and Löve (1956) as this species not agreeing with those treated under this name in Europe (Styles, 1962).

In Britain, the distinction between *P. arenastrum* and *P. aviculare* is rather sharp. Styles (1962) characterized *P. arenastrum* as having branch leaves about the same size as the stem leaves; persistent perianth divided about half its length; and fruits 1.5–2.78 mm long, with two convex and one narrowly concave side (rarely with two concave and one convex side). The chromosome number in this species was determined as  $2n = 40$ . In *P. aviculare* s. str. the branch leaves are smaller than those of the main stem (this is most evident in young plants); the persistent perianth is divided almost to the base; and the fruits are 2.5–3.5 mm long, with three more or less equal concave sides. The chromosome number is  $2n = 60$ . It should be pointed out that Lindman (1912) in an early paper on this group called *P. aviculare* s. str. *P. heterophyllum* Lindm. and *P. arenastrum* *P. aequale* Lindm., and that Löve and Löve (1956) called *P. aviculare* s. str. *P. heterophyllum* and *P. arenastrum* *P. aviculare*.

It became evident early in the course of our study that most of the North American collections referred to "*P. aviculare*" were *P. arenastrum*, and that plants referable to this species occurred throughout the temperate United States and southern Canada, and were occasional farther north. We determined the chromosome number  $2n = 40$  in two collections typical of this species: one from the Stanford University campus, Santa Clara Co., Calif., *Mertens 3* (DS), the second from Muncie, Indiana, *Mertens 10* (DS). In addition, this chromosome number was found in the root tips of germinating seeds from a collection from the serpentine area at Magalia, Butte Co., Calif., *Howell 37564* (CAS). In this collection, the achenes were nearly triangular in trans-section and ranged from 2.5–2.75 mm long. The perianth likewise was divided about  $\frac{2}{3}$  of its length, and the plant appeared to be relatively heterophyllous. As Styles (1962) points out, however, accurate determi-



nations of heterophylly can be made only in young, well grown plants. We encountered numerous collections which we referred to *P. arenastrum*, largely on the basis of fruit size, which did not have the characteristic single narrow concave side of this species; but we have likewise seen similar collections from southern Europe.

We have determined the chromosome number characteristic of *P. aviculare*,  $2n = 60$ , in the following two collections: about 5 miles north of Santa Cruz, Santa Cruz Co., Calif., along edge of an irrigated Brussels sprout field, *Mertens 5* (DS); State Highway 1 about 2 miles north of Santa Cruz Co. line, San Mateo Co., Calif., *Mertens 6* (DS). Although the perianth in these collections was deeply divided and the fruits typical of *P. aviculare* in transection, the fruits, very small for this species, were 2.25–2.5 mm long. Moreover, the plants were not appreciably heterophyllous. Both the small fruit size and the lack of heterophylly of these collections may have been attributable to the fact that both were late season plants which, growing in irrigated ground, had been flowering for a very long time before they were collected in late September. Nevertheless, they would have been most difficult to determine as *P. aviculare* had their chromosome number not been determined. Because we have seen relatively few collections from North America that were *P. aviculare*, it appears to be worthwhile to cite these. Doubtless it is much commoner than would appear here, as these weedy plants are poorly collected.

Alaska. Skagway, *Eastwood 734* (CAS). Yukon Territory. Moosehide Mountain, *Calder & Billard 4549* (CAS). British Columbia. Atlin, *Setchell & Parks, 1930* (CAS). Alberta. Near Fort Saskatchewan, *Turner 33* (CAS). Idaho. Kootenai Co.: valley of Lake Pend d'Oreille, *Sandberg et al. 966* (CAS). Nez Percés Co.: near Forest, *Brown 18* (DS). Nevada. Mineral Co.: Wassuk Range, *Archer 7165* (DS). Washoe Co.: Reno, *Eastwood 14795* (CAS). California. Del Norte Co.: Crescent City, *Van Deventer, 1934* (CAS); Kildale 1030 (DS). Humboldt Co.: near Cape Mendocino, *Wolf 1208* (DS). Shasta Co.: Mt. Shasta, *Cook 15403* (DS). Yolo Co.: Davis, *Goodwin, 1932* (DS). Madera Co.: Red's Meadows Pack Station, *Raven 3666* (CAS). Mono Co.: Hilton Creek, *Howell 27389* (CAS, immature). Sonoma Co.: Petaluma, *Eastwood 10476* (CAS). Marin Co.: Almonte salt marsh, *Howell 14814* (CAS); Greenbrae, *Howell 19428* (CAS). San Francisco: *Howell 32667* (CAS). San Mateo Co.: Redwood City, *Thomas 8784A* (DS; with *P. arenastrum*). Santa Clara Co.: near Mountain View, *Thomas 7239* (DS). Santa Cruz Co.: Pajaro River, *Thomas 3222* (DS). San Benito Co.: Hollister, *Raven 2150* (CAS). Tulare Co.: Terra Bella, *Howell & Barneby 29200* (CAS). Ventura Co.: Ojai Valley, *Pettibone & Hubby, 1894* (CAS). San Bernardino/Riverside Co.: Jurupa Mountains west of Colton, *Kamb 763A* (CAS).

In concluding this section it can be stated that *P. arenastrum* is much commoner than *P. aviculare* in North America and that both are more variable than would be suspected from the descriptions of Styles (1962). In general certain identifications can be made of plants with the characteristic fruit shape of *P. arenastrum* or with fruits averaging shorter than 2.25 mm; or of plants with fruits longer than 2.75 mm. Well grown plants with fruits between 2.25 and 2.75 mm in length are likely to be



*P. arenastrum* particularly if they are not heterophyllous and have the perianth divided about half of its length. The identification of late season plants with fruits falling in this range is likely to be problematical in the absence of chromosome counts; on statistical grounds they are most likely to be *P. arenastrum*. The identity of the plants discussed by Löve (1956) as *P. buxiforme* Small with a reported chromosome count of  $2n = 20$ , must remain problematical for the time being. Their *P. neglectum* Bess. and *P. aviculare* L., both with  $2n = 40$ , are probably *P. arenastrum*, and their *P. heterophyllum* Lindm. and *P. littorale* Link,  $2n = 60$ , *P. aviculare* L. Both of these species are introduced in North America.

9. *P. boreale* (Lange) Small. We have not seen specimens of this species from North America, but it has been reported from Arctic regions in this continent and is probably present.

*Doubtful and excluded species.* On the basis of the material we have seen, we are unable at present to evaluate the status of *P. autumnale* Brenkle (said by Löve and Löve, 1956, to have  $2n = 20$ ), *P. latum* Small (said by Löve and Löve, 1956, to have  $2n = 40$ ), and *P. montereyense* Brenkle (sect. *Duravia*?). A biosystematic study conducted along the lines of that carried out on British species by Styles (1962) would be necessary to evaluate the badly oversplit entities recognized in this group by some authors, notably Löve and Löve (1956), on the basis of very little evidence. Since these authors cite no specimens to document their chromosome number determinations, these reports must, in such a critical group, be disregarded.

One additional species of this group, *P. polycnemoides* Jaub. & Spach, has been reported by Hitchcock (1964, p. 163) from Idaho and New York; it is said to have shining achenes and to be distinguished from *P. aviculare* (sens. lat.) by its nonstriate, scaberulous-papillate and strongly angled stems, larger, less deeply lacerate stipules, and papillate perianth. It is a native of southern Asia, and, as suggested by Hitchcock, may occur more widely in North America than reported.

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## A REEVALUATION OF *BUDDLEIA CORRUGATA*

ELIANE M. NORMAN

As a thesis at the L. H. Bailey Hortorium, Cornell University, I prepared a revision of the North American species of *Buddleia* (Loganiaceae). This revision has not yet been published. However additional material from Baja California, Mexico, has recently become available which has made it necessary to alter the interpretation of two species treated in the thesis.

*Buddleia corrugata* was first collected by Marcus Jones at Arroyo Hondo (he spelled it Undo), Loreto, in October 1930. This locality lies at an altitude of approximately 2000 ft. on the north side of Cerro Giganta. The type collection is quite depauperate. Now with additional collections from several areas of Baja California, the species can be much better defined and the variability better evaluated. Material from the Cape Region which had been interpreted in my thesis as a different, if closely allied species, should be regarded as a subspecies of *corrugata*. Two recent collections from the area of Volcan Las Tres Virgenes are very similar to the type in morphology and it seems best to treat them also as a subspecies.

The pattern of variation in *B. corrugata* may be a reflection of the geologic history of Baja California. During pre-Pleistocene time the Cape Region was cut off repeatedly from the northern part of the peninsula (Durham and Allison, 1960) thus isolating the two areas and allowing divergent evolution to take place. The volcanic peaks of Las Tres Virgenes which arose in late Miocene (Savage, 1960) similarly provided an area where ecotypic variation could develop.

### KEY TO THE SUBSPECIES

Leaves ovate, 0.7-3.0 cm broad.

Lower surface of the leaves with erect pubescence, the stellate hairs candelabra;  
calyx 2.0-2.5 mm long; corolla 2.5-3.7 mm long; capsule 1.5-2.0 mm long

*B. corrugata* ssp. *corrugata*

Lower surface of the leaves with appressed pubescence, the stellate hairs mostly  
simple; calyx 3.0-4.0 mm long; corolla 4.0-5.5 mm long; capsule 2.5-3.0 mm  
long.....*B. corrugata* ssp. *gentryi*

Leaves linear, 0.2-0.3 mm broad.....*B. corrugata* ssp. *moranii*

**BUDDLEIA CORRUGATA** Jones, Contr. West. Bot. 18:56.1933, ssp. **CORRUGATA**. Shrub dioecious, 0.5–1.0 m high, with diffuse growth, the young twigs stellate-tomentose, the older branches greyish with rimose bark, the old naked branchlets persisting; leaves greyish-green with petiole 0.3–0.5 cm long, the stipular line inconspicuous, the blade ovate 1.0–3.0 cm long, 0.7–1.5 cm broad, thick erect stellate tomentum on both surfaces, underlain by glandular trichomes, the apex acute or obtuse, the base cuneate, somewhat decurrent, the margin strongly crenate or dentate; inflorescences sometimes branching at the base, with 3–15 pairs of sessile or short-pedunculate heads subtended by bracts, each head 0.5 cm in diameter usually with 5 flowers; calyx tubular, stellate outside, the tube 1.2–1.5 mm long, the lobes acute 0.5–1.0 mm long; corolla orange at maturity, campanulate, stellate-tomentose outside on upper half, the tube 1.7–2.5 mm long, with pitted hairs within, the lobes orbicular, spreading, 0.8–1.2 mm long; stamens subsessile, inserted on upper third of tube, the anthers 0.5 mm long, ovary oblong, 1.0–1.5 mm long, the style 0.5–0.8 mm long, the stigma 0.4–0.6 mm long, shallowly 2-lipped; capsule ovoid, 1.5–2.0 mm long, puberulent, opening septically and loculicidally at the apex, the valves separating broadly; seeds ovoid, wingless, approximately 0.5 mm long.

Northern portion of Sierra Giganta, at 2000–3000 ft. and limestone mesa of Monserrate Island (fig. 1). Flowering in the spring.

Type: Arroyo Hondo (Undo) Ranch, Loreto, Sierra Giganta, Oct. 26, 1930, *Jones 27361* (POM!, isotype at GH!).

Specimens examined. Rocky N facing slope, Valle de los Encinos, S side of Cerro Giganta, 750 m, *Carter & Reese 4570* (UC); Scandent on nearly vertical N facing cliffs of peak S of Portezuela de Peloteado, S of La Victoria, 1050 m *Carter & Medellin-Lean 4675* (UC); Locally common at N edge of limestone mesa, Monserrate I., 200 m, *Moran 9309* (SD).

**BUDDLEIA CORRUGATA** ssp. **gentryi** Norman, ssp. nov. Frutex 0.5–1.0 m altus; folia ovato-oblonga 2.0–6.0 cm longa, 1.0–3.0 cm lata primum utrinque appressa stellato-tomentulosa et glandulosa deinde superne glabrata, marginis inequale sinuatis; inflorescentia aliquando basi ramosa, axe principe 4–10 juga cymarum capitarum sessilium breviterve peduncularum ferente, capite quoque 0.7–1.0 cm lato, 3–5 floro; calyx tubiformis 3.0–4.0 mm longus; corolla aurantiaca campanulata tubo 2.8–3.8 mm longo intus piloso, extus stellato-tomentello, lobis orbiculatis patentibus, 1.0–1.5 mm longis; capsula ovata 2.5–3.0 mm longa dehiscentis; semina ovata, non alata 0.5 mm longa.

Differing from ssp. *corrugata* by the larger leaves with appressed tomentum on the underside (fig. 2) and larger flowers and fruits.

Southernmost part of the Magdalena Plain (fig. 1). Flowering in the spring.

Type: Arroyo Seco about 25 mi W of La Paz, arroyo margin at base of limy cliff, March 29, 1939, *Gentry 4446* (UC!, isotypes at ARIZ!, DS!, GH!, K!, US!).

Specimen examined. Arroyo Conejo near the mouth, *Moran 7455* (BH, CAS, DS, GH, RSA, SD, US, US).

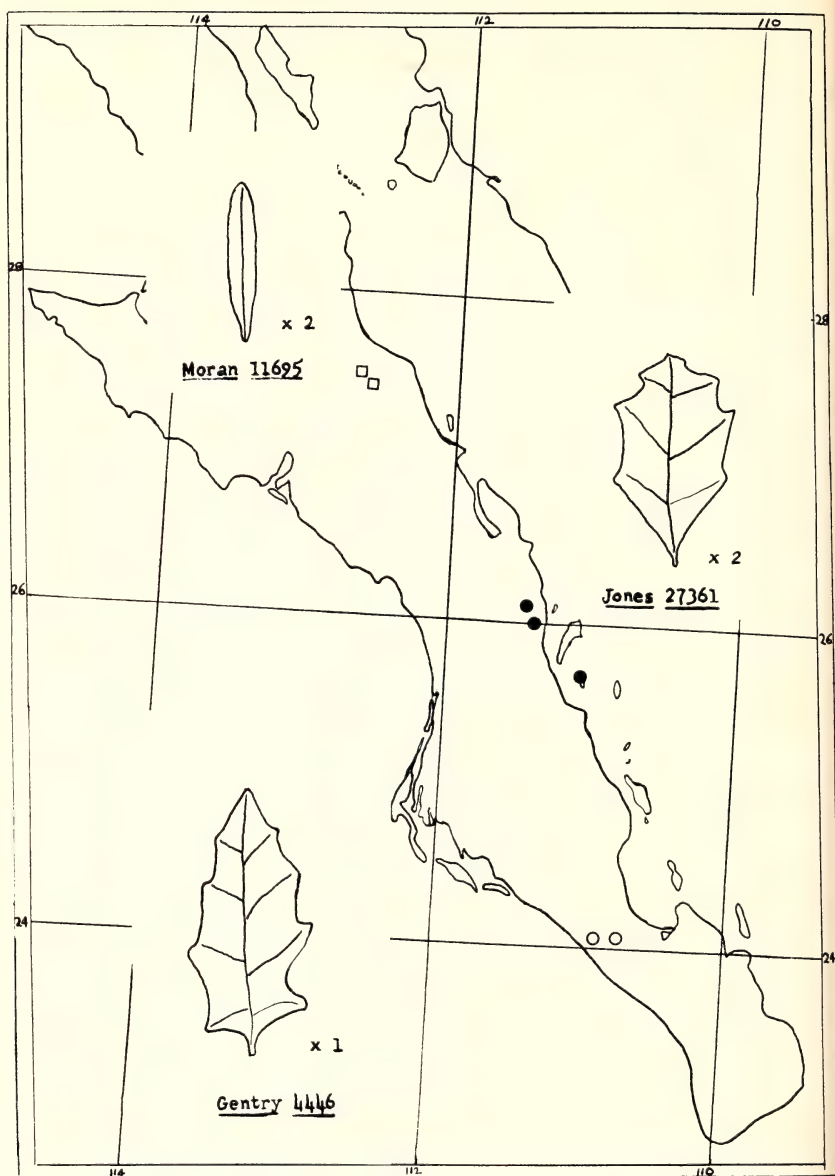


FIG. 1. Distribution of *Buddleia corrugata*; ssp. *corrugata*, closed circle; ssp. *gentryi*, open circle; ssp. *moranii*, open square.

*BUDDLEIA CORRUGATA* ssp. ***moranii*** Norman, ssp. nov. Frutex 0.5–1.0 m altus; folia lineares 0.5–2.0 cm longa, 0.2–0.3 cm lata, subsessiles, utrinque erecta stellato-tomentulosa, marginis aliquantum involutis, apice ovata, basi attenuata; inflorescentia 3–6 juga cymarum capitulum



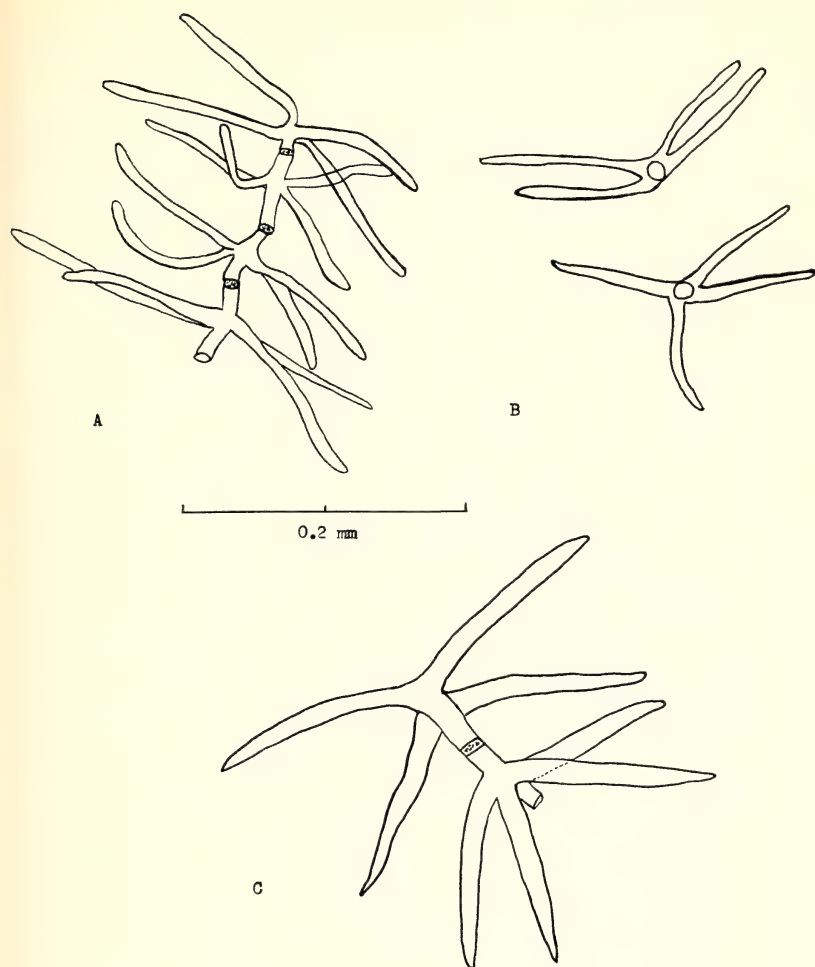


FIG. 2. Trichomes of underside of leaves of *Buddleia corrugata*; A, ssp. *corrugata* (Carter 4570); B, ssp. *genryi* (Gentry 4446); C, ssp. *moranii* (Moran 11695).

sessilium breviterve pedunculatarum ferente, capite quoque 0.5–0.7 cm lato, 3–5 floro; calyx tubiformis 3.0 mm longus, corolla aurantiaca, campanulata tubo 3.0–3.5 mm longo intus piloso, extus stellato-tomentello, lobis orbiculatis patentibus 1.0 mm longis; capsula ovata 2.5–3.0 mm longa dehiscens; semina ovata, non alata 0.5 mm longa.

Differing from ssp. *corrugata* and *genryi* by its much narrower linear leaves and shorter inflorescences.

Las Tres Virgenes Volcano, central Gulf Coast Region (fig. 1). Flowering in the spring.

Type: Volcan las Tres Virgenes, on cliff, steep arroyo on east slope from 1600–1900 m, Lat. 27° 28' N, Long. 112° 36' W, Feb. 12, 1964, *Moran 11695* (SD!).

Specimen examined. Crater of Volcan las Tres Virgenes, 1850 m, *Moran 11690* (SD).

It is very interesting to note the parallelism in leaf shape that has taken place in *corrugata* ssp. *moranii* and *B. utahensis*. Both have evolved in similar habitat—the latter is limited to the Mojave Desert at elevations of 800–1800 m, in an area where the mean annual rainfall rarely exceeds 15 cm (Clokey, 1951); it grows mostly on limestone and volcanic cliffs. The former, as already noted is known only from the Volcan las Tres Virgenes at elevations of 1600–1900 m, an area which lies in the driest subdivision of the Sonoran Desert with an annual mean rainfall of 13.8 cm (Shreve and Wiggins, 1964). I believe that this development in leaf structure is an instance of parallel evolution as it is very likely that *B. utahensis* and *B. corrugata* were both derived from *B. marrubiiifolia* stock.

*Buddleia corrugata* closely resembles *B. marrubiiifolia* of Texas and northern Mexico, differing in the size of the seed and the shape of the capsular valve. The westernmost element of that species, which seems to be a relict, possesses an inflorescence of several heads as does *B. corrugata*. This type of inflorescence is thought to be more primitive than the solitary head characteristic of *B. marrubiiifolia* ssp. *marrubiiifolia*.

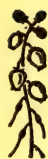
Judging from their great similarity, it would seem likely that *B. corrugata* and *B. marrubiiifolia* had a common ancestry. It is not known when *Buddleia* migrated to Baja California; it may have been in early Miocene or earlier when it is believed that the Gulf of California extended north only to the latitude of Tiburon Island. At that time direct interchange would have been possible between the Sonoran-Chihuahuan Desert and the peninsula (Wiggins, 1960).

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# MADROÑO

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## DR. LE ROY ABRAMS' COLLECTING TRIP OF 1908

ERNEST ALEXANDER MCGREGOR

In spite of the fact that I was registered as a Zoology major at Stanford University, I had by 1908 taken Botany courses every semester since matriculating. Incidental to receiving an appointment as assistant curator of the Herbarium, Professor Dudley informed me that I had taken more botanical courses than any previous student, to that time. This may have had something to do with the invitation of Dr. Abrams for me to accompany him on a botanical collecting trip during the summer of 1908 (fig. 1) to the mountains and Mojave Desert of Southern California.

Our trip commenced soon after the end of the spring semester and we made our first collection, *Calochortus clavatus*, on May 31 near Santa Paula. Our equipment was as frugal as consistent with the needs of successful collecting. Each of us had made a simple sleeping bag. A supply of provisions, such as desiccated soups, potatoes, rice, tea, coffee, and a few other needed supplies were shipped ahead to Hot Springs Camp, a short distance above Santa Paula. Naturally, a good supply of newspapers and heavy blotters were included. At the Springs we purchased six burros, two for riding and four for transporting equipment and specimens.

The camp wrangler gave us a hasty lesson in the tying of the diamond cinch, for securing the burden on the burros. The camp supplied a quantity of rolled oats, intended for inducing the untethered burros to stay near camp at night.

Our first day we headed toward Hines Peak and the Topatopa Mountains. As we were picking our way along a narrow mountain trail in the Topatopa Mountains (fig. 2), we were met by a typical old prospector who was laughing heartily. Said he: "Who showed you how to tie the diamond cinch?" A glance revealed that the packs of three of the burros had swung down, and were suspended under their bellies. The kind old fellow unpacked and repacked the loads, taking care to show us the secret of a good diamond cinch. The main idea is to pull the final tug of the rope so tight that the belly-band sinks into the animal's belly. When you hear the burro groan, the cinch is then just right.

On June 12 we camped near the base of Mt. Pinos. Being a hot day, we climbed to the summit of the mountain. Dr. Abrams and I stripped naked and bathed with handfuls of snow. We spent parts of two days at this location and found the collecting very good. We saw

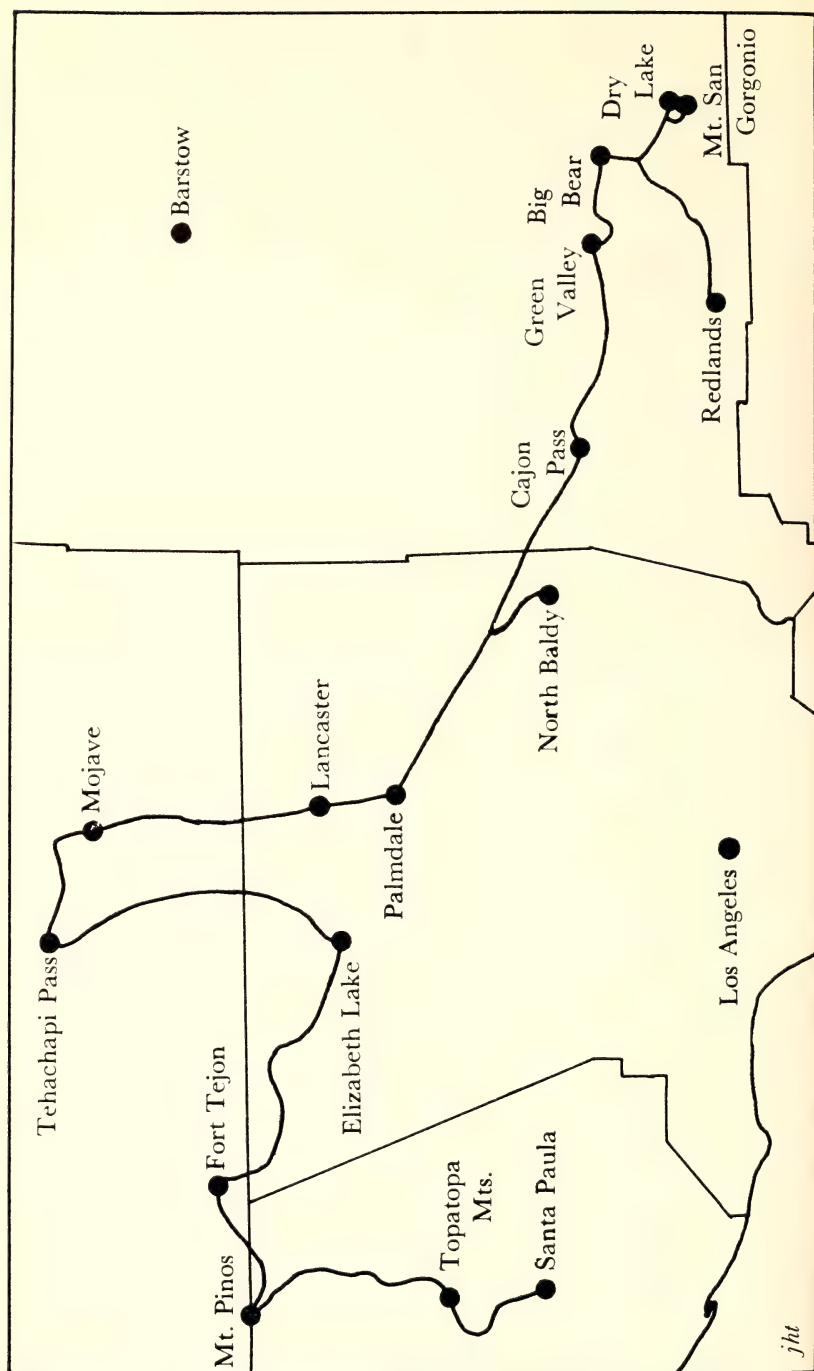




FIG. 2. McGregor leading the pack burros through the Topatopa Mountains.

trout in the pools, but had no fishhooks. We bent common pins, and attached them to stout thread and used grasshopper bait. To our great surprise we caught enough fish for a fine meal!

As we traveled through the domain of the limber pine, *Pinus flexilis*, we were impressed by their stunted and distorted condition. Little did we then suspect that the students of this tree would discover, many years later, that some of the limber pines are older than the big trees of the Sierra Nevada. It is claimed that some of them are over 4000 years old.

Continuing northeastward we collected at Fort Tejon and Gorman and marvelled at the profusion of noble valley oaks on the high plateau near the Fort.

Entering the desert (Antelope Valley), we inquired of an old prospector as to where we could find water at the eastern border of this arid area. He assured us that there was a spring at the eastern end of the desert trail. So we pressed on, collecting a good supply of desert species. As we were about to pass Neenach, a teacher, seeing our six burros, came out of the little one-room schoolhouse and she inquired if we would sell her a burro. She had a small boy of her own, and wanted the animal as a playmate for him. Our "Outlaw" was well named.

FIG. 1. Route of Abrams and McGregor through Southern California in 1908.





FIG. 3. Tehachapi Pass.

He had a mind of his own, and was a cause of some trouble and worry. He had a good physique, however. After some inspection—and with no discouragement from us—the lady agreed to purchase, and we sold him at cost.

At the end of our hot trek across the Antelope Valley, we reached the base of a foothill, where the old prospector had assured us we would find the locale for a good camp, and water. We soon spotted a spring, but at its bottom was a collection of drowned and putrid desert rats. Dr. Abrams and I discussed the situation, and we decided there was nothing to do but use the water. So we boiled potatoes and made coffee with the ill-smelling liquid! Next morning we again used the water for coffee and cereal. As we started toward Mojave via the Tehachapi Pass (fig. 3) and about 100 yards from where we had camped, we came upon a beautiful spring of crystal pure water. Many a time Abrams and I joked about this incident.

The hike to Mojave was on a very hot, trying day and, as I recall, we collected a minimum of plants. As we were struggling along, with parched throats, two men on a buck-board overtook us and stopped to pass the time of day. Probably noting our discomfort, one of them asked: "How would you like a cool bottle of beer?" Not waiting for an answer, he reached into an ice container and handed each of us a bottle. That was another incident that Abrams and I often mentioned in later years.

In 1908 Mojave was little more than a section-point, where the Santa



Fe trains took on water and changed crews. As we and our five burros trudged into town, we wondered where to make camp. We were a dirty, unshaven, doubtful looking pair, and dreaded the reception we might receive, even at the questionable looking tavern. We came upon a horse corral, deep with straw and manure and supporting a million flies. In desperation, we pitched camp there.

Since the start of our trip at Santa Paula, we had subsisted entirely on our crudely prepared camp meals and here at Mojave was a Harvey Cafe! Why not buy a real meal? So, in hobo attire, into Harvey's we tromped. A group of properly dressed gents eyed us, and one of them said: "Look, see what's coming!" That, of course, was another incident that Abrams and I recalled.

Next day we headed for Lancaster, across the Mojave Desert, abounding with Joshua trees, *Yucca brevifolia*. This was to be a two-day hike with a night camp at a small ranch. After a broiling-hot day, it seemed good to crawl into our sleeping bags and in the cool of the night gaze up at the millions of crystal-clear stars.

As we were about to fall asleep, I heard Abrams say: "What's that noise I hear?" Then I too heard the somewhat alarming noise. We arose and with a flashlight crept toward the point of the sound. *There* was a domestic cat holding its paw as if in self-protection. Suddenly our light revealed the cause of the noise—a rattlesnake coiled to strike. We found a suitable stick and killed the rattler. In the morning we saw that the coiled snake had been about two feet from our heads—in the sleeping bags. There was no trace of the cat.

That morning we noted that our food supply was getting scarce and we planned to stock up at Lancaster. We found botanical material much more abundant than one would expect in a desert and we secured a gratifying number of specimens. As we toiled along toward the western border of the desert, we were a sweating but jolly pair. Dr. Abrams could hardly be called the athletic type and he rode nearly the full distance of the summer trip. Having run the mile on the Stanford track team, with many an hour of training, it was perhaps natural that I preferred walking to sitting astride a groaning little burro.

As the hours passed in our trek toward Lancaster, the continuing sameness drugged us into a state of semi-hypnosis. Early that day I had asked Abrams for the technical name of a composite that abounded as we traversed the Mojave Desert. He informed that it was *Hymenoclea salsola*, burrobrush, and in my drowsy condition, I began chanting: "Hy-men-o-clea sal-so-la." I must have chanted these names intermittently for hours and finally Abrams joined me in the chanting. If anyone had come upon us as we chanted, they might have questioned our sanity.

As we came to the outskirts of Lancaster, we made camp near a factory of some sort. Upon finishing our desert supper, a man approached us and presented us with a bottle of cool claret. He was an Italian worker



FIG. 4. Abrams examining *Pinus flexilis* at the summit of Mt. San Gorgonio.

in the factory, a modest fellow, and when we thanked him feelingly for the very welcome gift, he bowed and said it was *not* much. Though Abrams might have been classified as an abstainer, I recall that we finished the bottle and slept the sleep of weary but contented travelers.

One of our problems was to be able to ship our accumulation of plants often enough to adjust to our active collecting. The hot dry climate of many of localities we visited, favored rather speedy drying of the plants. It often was a considerable distance between express offices and at times the little burros became heavily laden by the time we reached a shipping point. Thus we were glad to unload at Palmdale. It is well to explain here that arrangements had been made with Miss Josephine Randall, then a zoology major, to care for the plants as they arrived at Stanford University. Luckily, she was a very careful and dependable person.

From Palmdale we travelled through Cajon Pass to Lake Arrowhead and Big Bear Lake, in both of which localities the collecting was good. We next visited Dry and Dollar lakes. The latter was a very small, circular body of water near the base of Mt. San Gorgonio at an elevation of about 9300 feet. It had a very attractive setting and we could not resist making it our camp for parts of two days. At such an elevation we found a limited but very interesting flora and we collected with enthusiasm.

While at Dollar Lake, we had a sudden inspiration to hike to the summit of Mt. San Gorgonio. At best, the trail was rather poor, and





FIG. 5. Matilija poppy, *Romneya trichocalyx*, along Sespee Creek, Ventura Co.

gradually deteriorated as we climbed until, at about the 10000-foot level, the trail vanished and we had to pick our way the remaining distance. The view from the summit (fig. 4) of the highest mountain in Southern California (11485 feet) was inspiring! We could see the Imperial Valley and the northern zone of Baja California. We were well above timber line and with the exception of stunted *Pinus flexilis*, the mountain was practically devoid of flora.

On return to Dollar Lake, a look at our map indicated that it was about 30 miles to Redlands, our final point of travel. Planning to take parts of two days to reach our destination, we followed Mill Creek Canyon at an easy pace for man and animal, collecting as we went. Reaching Redlands, our purpose had been accomplished and the final shipment of specimens was dispatched. At Redlands we found a tourist outfitter who purchased our five burros, "Ari", "Zona", "Razor", "Maybe", and "Groaner". They had served us patiently and effectively. We received nearly as much for them as they had cost us originally. Considering the net outlay and the total mileage covered (estimated 400 miles), the burros furnished us very cheap transportation. During the six weeks of our intimate association with the peaceful, friendly animals, Abrams and I could not but help forming a sort of fellowship with them. For my part, I felt that I owed them a debt for the contribution they made toward obtaining the botanical specimens.

Upon returning to the Stanford Campus, we found that our many days of rugged toil had been made more valuable by the final attention given to the material by Miss Randall upon receipt.

As we gathered plants on the trip, we tried to collect four or five specimens of each species at each locality. Thus there were several more or less complete sets in the entire collection. Stanford retained a complete set and the others were sold to the herbaria of the New York Botanical Garden, the Smithsonian Institution, the Royal Botanical Garden of Edinburgh, the Jardin botaniques in Genève, Harvard University, and the University of Zürich. Dr. Abrams very generously split the balance with me after all expenses were deducted. My half, as I recall, amounted to roughly \$75.

During the entire trip, no accidents occurred and neither Dr. Abrams nor I incurred any physical ailments. I don't seem to recall any rainfall that caused any worry. All that can be said for our food and cooking is that it didn't poison us and it did maintain our bodily functions. With the exception of a week's supply of rolled oats, the burros kept in seemingly good condition by grazing upon the grass and other burro eatables they could find in and around camp. What plant impressed me the most during the entire trip? I am inclined to select the matilija poppy, *Romneya trichocalyx* (fig. 5).

I would be very remiss were I not to record that I cannot recall any unkind attitude or remark ever occurring throughout the entire duration of the collecting trip. To characterize Dr. Abrams in the vernacular, he was a "darn good scout," and an ever pleasant companion. I have thought and spoken of the trip many times. It was one of the high spots in my life!

128 S. Washington Ave., Whittier, California

## NOTES AND NEWS

CALIFORNIA NATIVE PLANT SOCIETY.—The rapid population growth in California will inevitably result in the reduction or even extinction of endemic plants in many parts of the State. The California Native Plant Society was established in July to counteract this threat to the native flora. This is a statewide, non-profit, educational, and charitable organization specifically concerned with the conservation of the California flora. It will cooperate with other conservation groups in this task. The organization consists of members at large and a program involving the formation of local chapters is being initiated. The sponsors of the California Native Plant Society include a number of distinguished California citizens. Information on the programs of the Society can be obtained from P. O. Box 397, Berkeley, California 94701 or from the Jepson Herbarium, University of California, Berkeley, California 94720. Membership dues include a monthly newsletter and a quarterly publication.



# THE FLESHY-FRUITED GALIUM SPECIES OF CALIFORNIA (RUBIACEAE).

## I. CYTOLOGICAL FINDINGS AND SOME TAXONOMIC CONCLUSIONS

LAURAMAY T. DEMPSTER AND G. LEDYARD STEBBINS

Preliminary work by the senior author, done under the auspices of the Jepson Herbarium, demonstrated the presence of morphological, cytological and taxonomic complexity in the fleshy-fruited species of *Galium* of California. It was apparent that only by further study of the chromosomes would it be possible to determine the interrelationships between the many existing forms. This study was undertaken in 1963 and 1964, supported by the National Science Foundation, grant number GB649. It has involved an intensive and extensive field investigation, including visits to a number of areas where the plants had not been previously collected. Chromosome counts were made chiefly from somatic cells of leaf buds, either preserved in the field or taken later from transplanted individuals. Material was pretreated with a saturated aqueous solution of paradichlorobenzene before fixing, as a result of which pretreatment the shape of the chromosomes as seen in the figures has been considerably altered.

We wish to thank Rimo Bacigalupi, Curator of the Jepson Herbarium, for generous provision of laboratory space, and for critical reading of the manuscript.

The plants under consideration are dioecious, have four "leaves" to a node (with the exception of *G. hardhamiae* and sometimes *G. clementis*), and bear fleshy fruits, a character unusual in this genus. The species that comprise the group are *G. californicum* H. & A., *G. nuttallii* Gray, *G. bolanderi* Gray (including *G. pubens* Gray), *G. andrewsii* Gray, *G. ambiguum* Wight, *G. sparsiflorum* Wight, *G. miguelense* Greene, *G. muricatum* Wight, *G. clementis* Eastw., *G. grande* McClatch., and *G. hardhamiae* Dempst.

The group is restricted to California, southern Oregon and northern Baja California. Within this area it occupies most of the cismontane hilly and mountainous areas, from ocean bluffs at near sea level to almost 8000 feet in the Sierra Nevada.

Considered from the traditional morphological and geographic points of view, the species have in the past proven difficult to delimit. Many specific names have been published to cover the various forms, and all attempts to evaluate these by classical taxonomic means have been unsatisfactory, owing to the great diversity of forms within what appeared to be the chief divisions or species, and to marginal resemblances be-

tween these species. Preliminary chromosome counts showed the existence of polyploidy, and an attempt has therefore been made by further cytological study to arrive at a clearer understanding of the taxonomic divisions, and eventually of the evolutionary pattern within the group.

The present paper has as its purpose the publication of chromosome numbers (table 1, figs. 1, 2) together with some taxonomic conclusions to be derived therefrom. Our new knowledge of ploidy levels within the group has clarified a number of previously obscure taxonomic lines, such as those between *G. californicum* and *G. nuttallii*, and between *G. bolanderi* and *G. sparsiflorum* or *G. nuttallii*. It is hoped, therefore, that a systematic revision based on these new data will shortly follow. Voucher specimens for all chromosome counts will be deposited in the herbarium of the University of California at Berkeley, except those already in the Jepson Herbarium.

The fleshy-fruited *Galium* complex is now known to consist of one widely distributed and polymorphic diploid species, *G. nuttallii*, at least six other more restricted and more uniform diploid species, and at least ten polyploids, most of which are apparently hybrids. All of the diploids can be related readily to one or more polyploids and vice versa, the result being a network of polyploids and diploids in which most, or perhaps all, of the taxa are connected to each other, directly or indirectly.

In the following paragraphs, some specific taxonomic conclusions are set forth, and two new taxa are described.

The epithet *pubens*, derived from *Galium pubens* Gray, the application of which has always been vague and uncertain, is now clearly seen to be unnecessary. Field observation has repeatedly shown us that very pubescent forms referable to *G. pubens* grow in very close association or even in contact with glabrous or glabrate forms of *G. bolanderi*, and that highly diverse populations are common, containing plants of all degrees of pubescence. Since we now know that all of these varying elements of such populations are hexaploid, there seems no good reason to doubt that they are merely genetic segregates in freely interbreeding populations of *G. bolanderi*.

*Galium grande* McClatch., which has sometimes been confused with *G. pubens* in the herbarium and in the literature, is not only quite distinct in the field, owing to its more fleshy leaves and its lavishly sprawling habit, but is now known to be a very high polyploid, perhaps 20x. It must therefore stand as a species. It was subordinated to *G. pubens* as a variety by Jepson (1925), Munz (1959) and Ferris (1960), and in the latter instance was defined so as to include much pubescent material of *G. bolanderi* from the southern Sierra Nevada.

*Galium sparsiflorum* Wight is now known to be a diploid species, a fact which greatly eases the matter of differentiating it from some forms of *G. bolanderi*. The latter species is always hexaploid, although some individuals resemble the diploid taxa *G. sparsiflorum* or *G. nuttallii*. The inference is very strong that one genome from each of the latter two

species is present in *G. bolanderi*, together with a third genome from some pubescent species. True *G. sparsiflorum* can be distinguished from sparsifloroid individuals of *G. bolanderi* by the narrow leaf insertion, the very slender pedicels, and often by the leaf texture, which may be thin or somewhat coriaceous, but is never soft and thick as is common with *G. bolanderi*.

*Galium muricatum* Wight, which was included under *G. californicum* by Jepson but was recognized as a species by Munz and by Ferris, is clearly a separate species. It has been observed repeatedly by us in the field, growing in closest association with *G. californicum* without intergrading. Furthermore, cytological study shows the two species to be far apart in their chromosome numbers, *G. californicum* being, except for the very local ssp. *luciense*, highly polyploid, and *G. muricatum* of low ploidy. The latter is apparently always diploid south of Albion, Mendocino Co., and tetraploid north of Fort Bragg. No consistent difference between the diploid and tetraploid series of populations has yet been found.

***Galium cliftonsmithii*** (Dempster) Dempster & Stebbins, comb. nov. *Galium nuttallii* Gray var. *cliftonsmithii* Dempster, Brittonia 10:183. 1958. Studies since 1958 indicate *G. cliftonsmithii* to be a high polyploid, while *G. nuttallii* is consistently diploid throughout its many forms. The closest relative of *G. cliftonsmithii* is probably *G. californicum*, especially the typical form from the Monterey coast, but the large, shiny, coriaceous and acrose leaves, vigorous habit and higher chromosome number of *G. cliftonsmithii* entitle it to specific rank.

**GALIUM CALIFORNICUM** H. & A. ssp. ***luciense*** Dempster & Stebbins, ssp. nov. Plantae perennes dioicae humiles (usque ad 16 cm), caulibus pluribus e rhizomatibus tenuibus diffusis orientibus, ubique molliter pubescentes pallide virides; folia pusilla, 4–6 (10) mm longa, plana vel leviter revoluta, carnosula, elliptica vel leviter obovata, apicibus inermibus; corollae rotatae, galbinae; ovaria dense pubescentes; fructus albi carnosi; chromosomata 44.

Type. Cone Peak, Monterey Co., California, T. 21 S., R. 4 E., Oct. 12, 1960, at about 4000 feet, *Dempster & Hardham 1403* (JEPS 24912). Named for the Santa Lucia Mountains.

Additional collections Monterey Co.: Cone Peak trail ca.  $\frac{3}{4}$  mile north of road-head, ca. 4500 feet, *Dempster & Stebbins 3921*. Specimens from the ridge between Mill Creek and Alder Creek, Monterey Co., *Hardham 3785*, with very small stomata, appear to be of this subspecies.

The plants are not conspicuously tufted, the many annual stems arising separately from extensive underground rhizomes, clones often covering many square feet. Apparently of very local distribution, ssp. *luciense* grows in forest duff or gravelly talus in partial shade, with *G. clementis* on Cone Peak, Monterey Co. It was supposedly derived as an allotetraploid from *G. clementis* with some other diploid. It shares with *G. clementis* the distinctive light color and dense, soft long hairs. It is readily distinguished from that species, however, by its habit, which

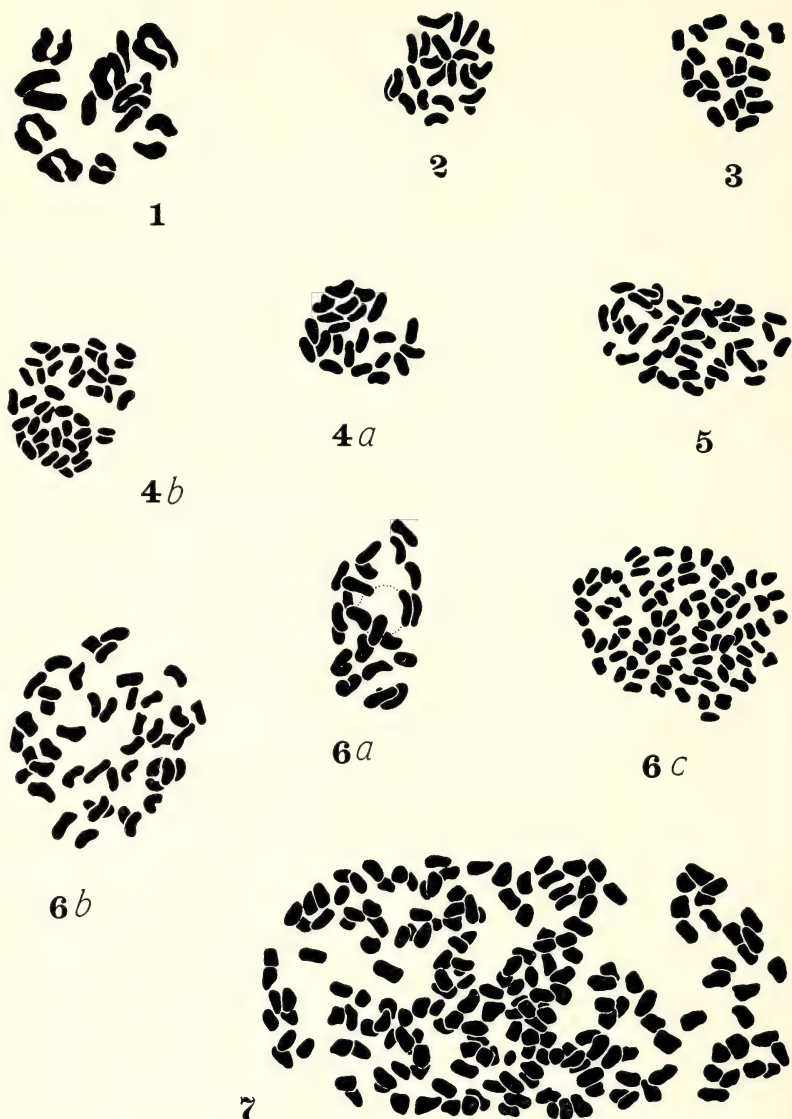


FIG. 1. Camera lucida drawings showing chromosome numbers in species of *Galium* ( $\times$  ca. 2000). No. 1 is meiotic from P.M.C., the rest mitotic from shoot terminals. 1, *G. sparsiflorum*, 3807,  $n = 11$ . 2, *G. clementis*, 1402,  $2n = 22$ . 3, *G. nuttallii*, 3968,  $2n = 22$ . 4a, *G. muricatum*, 3944,  $2n = 22$ ; 4b, *G. muricatum*, 3957,  $2n = 44$ . 5, *G. martirense*, 3987,  $2n = 44$ . 6a, *G. andrewsii*, 6151,  $2n = 22$ ; 6b, *G. andrewsii*, 3983,  $2n = 44$ ; 6c, *G. andrewsii* var. *gatense*, 4079,  $2n = 88$ . 7, *G. cliftonsmithii*, 3970,  $2n =$  ca. 187. All mitotic chromosomes were pretreated with saturated aqueous solution of paradichlorbenzene.



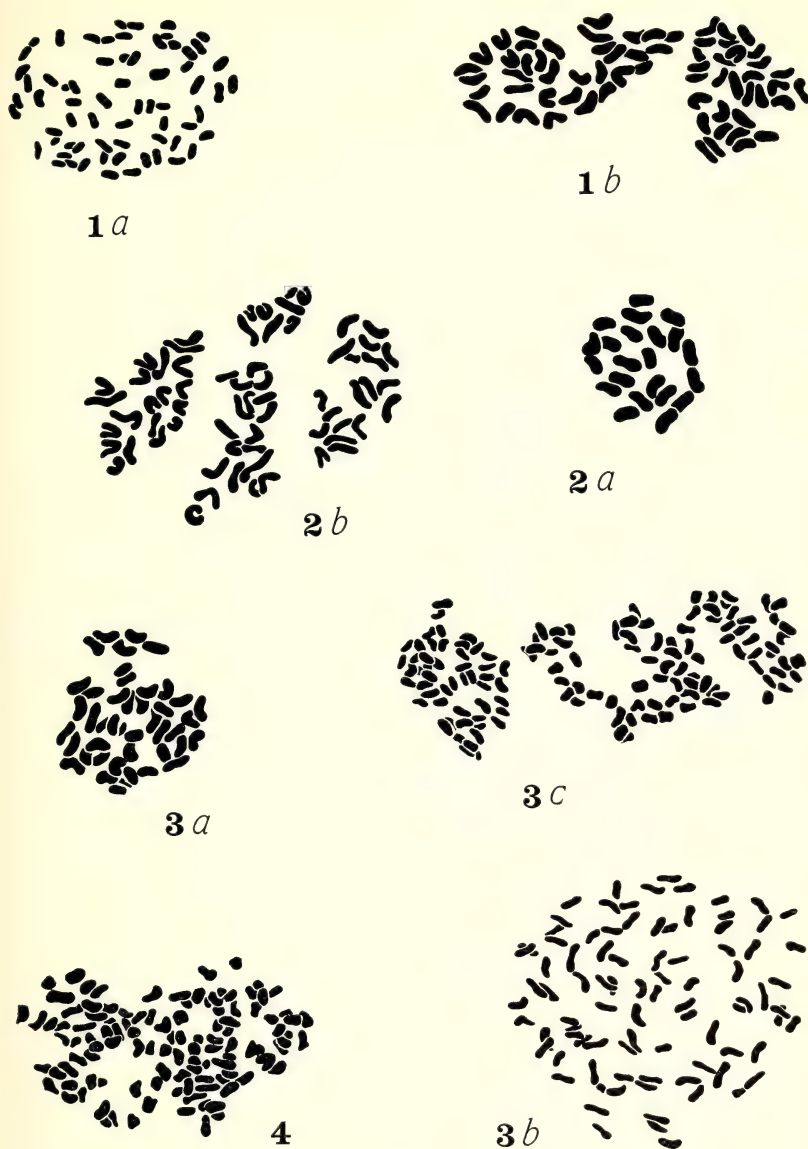


FIG. 2. Camera lucida drawings showing chromosome numbers of species of *Galium* ( $\times$  ca. 2000). No. 4 is meiotic from P.M.C., the rest mitotic from shoot terminals. 1a, *G. bolanderi*, 3806,  $2n = 66$ ; 1b, *G. bolanderi* ("*G. pubens*"), 3797,  $2n = 66$ . 2a, *G. ambiguum*, 4034,  $2n = 22$ ; 2b, *G. ambiguum* var. *siskiyouense*, 3913,  $2n = 66$ . 3a, *G. californicum* subsp. *lucense*, 3921,  $2n = 44$ ; 3b, *G. californicum*, 3979,  $2n = 88$ ; 3c, *G. californicum*, 3898,  $2n = 132$ . 4, *G. grande*, 3975, Anaphase I, 1 pole,  $n =$  ca. 110. All mitotic chromosomes were pretreated with saturated aqueous solution of paradichlorbenzene.

is generally lower and much less tufted; by the shape of the leaves, which are considerably broader and not notably revolute; and by the number of leaves, which is invariably four, whereas *G. clementis* often bears five or six to a node. Subspecies *luciense* is, however, less easily distinguished from some forms of octoploid *G. californicum* in the Cone Peak area. Although ssp. *luciense* is relatively uniform in appearance, the octoploid has many forms throughout its range. On the lower slopes of Cone Peak it sometimes resembles ssp. *luciense* rather closely.

On the top of Cone Peak, *G. clementis* is found growing alone. A little lower down, it grows with *G. californicum* ssp. *luciense*. Still lower, *G. clementis* drops out and octoploid *G. californicum* makes its appearance. Lower still ssp. *luciense* drops out, leaving only the octoploid in diverse forms, some very like ssp. *luciense*, a few with narrow leaves suggestive of the deep-shade form of *G. clementis*, but the greater part broad-leaved, flaccid and easily distinguished from both the diploid (*clementis*) and the tetraploid (*luciense*). The new tetraploid taxon may be supposed from its very close morphological resemblance to many forms of *G. californicum* to have been one of the ancestors of that species, and to give us a clue as to the way in which the diploid species *G. clementis* may have contributed to the composition of the modern polymorphic species known as *G. californicum*. It is for this reason, and because of the practical difficulty of differentiating it from some forms of octoploid *G. californicum*, that we have described it as a subspecies of this complex polyploid, rather than as a species.

***Galium martirense*** Dempster & Stebbins, sp. nov. Plantae perennes dioicae 12–50 cm altae, e radicibus robustis caespitosae, caulibus plerumque tenuibus lignosis vix scandentibus, ubique molliter pubescentes pallide virides; folia 5–12 mm longa, apicibus inermibus, plerumque elliptica vel anguste ovata revolutaque, sed nonnumquam latiores vix revoluta; corollae rotatae albo-flavae extus hispidae; fructus carnosi; chromosomata 44.

Type. Oaks Pasture, 15 miles by crooked road northeast of the Meling Ranch (Rancho San José), about 20 air miles east of San Telmo, Baja California, *Dempster & Cory* 3987 (UC 1199709). Named for the San Pedro Mártir Mountains.

Additional collections. Sierra de Juárez: 1 mile south of Rancho Viejo, *Moran* 9845 (UC), Ensenada (certainly east of), *Jones* 3692 (UC), *Howell* (CAS). Sierra de San Pedro Mártir: northeast of the Meling Ranch (Rancho San José), east of San Telmo, *Dempster* 3989 (UC), 3990 (UC), 3991 (UC), *Robertson* 12 (UC), *Moran* 10950 (UC).

Habitat: Sierra de Juárez and Sierra de San Pedro Mártir, Baja California, at 3000 to 5600 feet; in shelter of trees, shrubs or boulders, with *Quercus*, *Adenostoma*, *Artemisia*, *Arctostaphylos*, *Chrysothamnus*.

In growth habit, *G. martirense* somewhat resembles *G. nuttallii*, or even more one of its polyploid derivatives, such as *G. bolanderi*, or coastal forms of *G. californicum*. The primary stems are usually elongated, with nodes sometimes as long as 8 cm, becoming woody but remaining slender and serving as a scaffold for subsequent herbaceous and more congested

fertile growth. The species is most similar to *G. grande* McClatchie, which it resembles more in the herbarium than in the field. Both species are hairy, and often become very dark when dry, the hairs then appearing brownish or white against the blackish chlorenchyma. In habit *G. martirens* is more tufted and the stems are straighter than in *G. grande*, which is decidedly weak and sprawling as well as larger. The leaves of *G. martirens* are generally (although not always) narrower than those of *G. grande* and are noticeably revolute, in contrast with the broader and fleshier, relatively plane leaves of *G. grande*. Nevertheless, a small minority of plants of *G. martirens* with broader leaves and less obviously tufted habit resemble rather closely, at least in the herbarium, a small minority of plants of *G. grande* with narrower leaves or stiffer habit. What at first appears to be a very close relationship is thus not supported by closer inspection, since in addition to the differences in habit and leaves and the wide geographic separation, we find a great difference in chromosome number, *G. martirens* being of low ploidy (4x) as contrasted with the very high ploidy (possibly 20x) of *G. grande*.

*Galium martirens* seems very closely akin to the diploid species *G. clementis* Eastwood, with which it shares, in most individuals, the narrow, revolute leaves and the pale softly hispid character. *Galium martirens* is, however, a much larger and stiffer plant in every way, with a fair range of morphological variation. *Galium clementis* is apparently restricted in present times to the northern Santa Lucia Mountains in Monterey County, California, and if it was parental to *G. martirens*, it must be supposed that it had formerly a much greater range. If *G. martirens* is an allotetraploid between a *clementis*-like ancestor and some other diploid, the identity of the second ancestor is not apparent. Resemblances to *G. nuttallii* Gray, which in some places grows with it are, except for habit, slight.

TABLE I. CHROMOSOME COUNTS IN GALIUM SPECIES OF THE FLESHY-FRUITED GROUP

Collection numbers are those of Dempster, or Dempster and Stebbins, unless otherwise indicated.

*G. nuttallii* Gray var. *nuttallii*.  $2n = 22$ . San Diego Co., Mt. Helix, 3911; Baja California, Socorro Mine, Dempster 3991A; Santa Cruz I., 4085.

*G. nuttallii* Gray (other varieties).  $2n = 22$ . Contra Costa Co., Orinda, 3805; Humboldt Co., Bull Creek, 3856, Briceland, 3887, Shelter Cove, 3888; Los Angeles Co., Dalton Canyon, 3978; Madera Co., North Fork, 3813; Marin Co., Tiburon, Stebbins s. n.; Mendocino Co., Albion, 3881, Anchor Bay, 3948, Newport Hutchison 887 (JEPS); Monterey Co., Arroyo Seco Public Camp, Bacigalupi 7561 (JEPS); Napa Co., Saint Helena, 3780B, 3780E; San Benito Co., Clear Creek, 4077; San Luis Obispo Co., San Luis Obispo, 3960; Santa Barbara Co., Buellton, 3962, Nojoqui Falls, 3965, Refugio Pass, 3968; Santa Cruz I., 4082, 4088; Trinity Co., Mill Creek, 3841; Ventura Co., Ojai, Dempster s. n. (JEPS); Josephine Co. Oregon, Merlin, Hutchison 2065 (JEPS).

*G. sparsiflorum* Wight.  $n = 11$ . Fresno Co., Shaver Lake, 3818; Madera Co., Whiskey Creek, 3807; Tuolumne Co., Crane Flat, 4035.  $2n = 22$ . Placer Co., Baxter, 1443 (JEPS); Tehama Co., Potato Patch, 4050.

*G. hardhamiae* Dempst. **2n** = **22**. San Luis Obispo Co., Cypress Mountain, 5703 (JEPS).

*G. clementis* Eastwood. **2n** = **22**. Monterey Co., Cone Peak, 1402 (JEPS), *Dempster s. n.*

*G. andrewsii* Gray. **2n** = **22**. Fresno Co., Los Gatos Creek, 4074, 4075; Kern Co., Bodfish, 1437 (JEPS); Monterey Co., Castle Peak, 4066, 4065, 4069; Lake Co., Butts Canyon, *Stebbins* 6151; Napa Co., Corona Mine, *Stebbins* 6160; San Benito Co., Clear Creek, 4078; San Luis Obispo Co., Morro Bay, *Stebbins s. n.*; Tehama Co., west of Paskenta, 3995, Patton Mills, 3997, Colyear Springs, 4006. **2n** = **44**. Los Angeles Co., Gorman, 3983; San Luis Obispo Co., Kiler Canyon, 4073.

*G. andrewsii* Gray var. *gatense* Dempst. **2n** = **88**. Monterey Co., Parkfield-Coalinga summit, 4072, Table Mountain, 4064 (D1 & D3); San Benito Co., Clear Creek, 4076, 4079, Idria Summit, 4080; Santa Clara Co., Mt. Hamilton, 4062.

*G. andrewsii* x *nuttallii* (natural hybrid). **2n** = **22**. Tehama Co., Round Mountain, 4002.

*G. ambiguum* Wight. **2n** = **22**. Humboldt Co., Low Gap, 3854; Shasta Co., Harrison Gulch, 4009, Regan Meadow, 4010; Tehama Co., Riley Ridge, 4003, Ball Rock, 4004, Round Mountain, 4001; Trinity Co., southeast of Peanut, 4012, west of Peanut, 4013, South Fork Mountain, 4022, Ruth to Zenia, 4026, Ruth, 4019.

*G. ambiguum* Wight var. *siskiyouense* Ferris. **2n** = **66**. Del Norte Co., Gasquet, 3912, 3913, Happy Camp Road, 3917.

*G. muricatum* Wight. **2n** = **22**. Humboldt Co., Manchester, 3896; Mendocino Co., Hendy Redwoods, 3878, Navarro, 3880; Sonoma Co., Stewart's Point, 3944, 3945. **2n** = **44**. Humboldt Co., Willow Creek, 3845 (A & B), Larrabee Valley, 3851, Dinsmore's, 3852, Bull Creek, 3858, Weott, 3860, Orleans, 3919, Boise Creek, 3920, Richardson Grove, 3957 (1 & 2); Mendocino Co., Laytonville, 3871, Branscomb, 3950 to 3954, Leggett, 3956 (1 & 3), Willits, 3958.

*G. martireense* Dempst. & Stebb. **2n** = **44**. Baja California, above Meling Ranch, 3987.

*G. bolanderi* Gray (including *G. pubens* Gray). **n** = **33**. Butte Co., Jonesville, 4048; Humboldt Co., Orleans, *Hutchison* 2031 (JEPS); Madera Co., Oakhurst, 3806 (11 & 12), South Fork, 3809, 3810; Placer Co., Baxter, 1442 (JEPS); Napa Co., Angwin, 3782A; Plumas Co., Quincy, 1458 (JEPS). **2n** = **66**. Humboldt Co., Dinsmore's, 3853, Berry Summit, *Hutchison* 2010 (JEPS); Lake Co., Glenbrook Resort, 3797B; Madera Co., Oakhurst, 3805½, 3806 (2, 3, 4, 5 & 7), Whiskey Creek, 3808 (1 & 2), South Fork, 3811, North Fork, 3814; Mariposa Co., Usona, 3820; Plumas Co., Graeagle, 1456 (JEPS); Shasta Co., Hat Creek, 4053; Siskiyou Co., Happy Camp, 3918, *Hutchison* 2039 (JEPS); Trinity Co., Burnt Ranch, 3842.

*G. californicum* H. & A. subsp. *luciense* Dempst. & Stebb. **2n** = **44**. Monterey Co., Cone Peak, 1403 (JEPS), 3921.

*G. californicum* H. & A. sensu lato. **n** = **44**. Monterey Co., Kirk Creek, 3939. **2n** = **88**. Los Angeles Co., Glendora Ridge, 3979; Monterey Co., Cone Peak, 3922 to 3928, 3933 to 3935, Nacimiento, 3936, 3937; Santa Barbara Co., Nojoqui Falls, 3963, 3964, Refugio Pass, 3969. **2n** = ca. **88**. Monterey Co., Cypress Mountain, 1187 (JEPS); Santa Barbara Co., Buellton, 3961. **n** = **66**. Marin Co., Mt. Tamalpais, *Bacigalupi* 8880 (JEPS); Trinity Co., Ruth Lake, 4017. **2n** = **132**. Humboldt Co., Manchester 3898; Mendocino Co., Stewart's Point, 3907; Monterey Co., Point Lobos, 4081; Santa Cruz Co., Boulder Creek, *Stebbins s. n.* **2n** = ca. **132**. Humboldt Co., Bridgeville, 3848, Manchester, 3897; Mendocino Co., Anchor Bay, 3909, Laytonville, 3872, 3955, Bell Springs, 3866, Hendy Redwoods, 3877; Santa Cruz Co., Santa Cruz, *Stebbins s. n.*

*G. cliftonsmithii* (Dempst.) Dempst. & Stebb. **2n** = c. **182-189**. Santa Barbara Co., Refugio Pass, 3970.

*G. grande* McClatchie. **n** = more than **110**. Los Angeles Co., Chantry's Flat, 3975.



## SUMMARY

Chromosome counts are published for all mainland species of the fleshy-fruited species of *Galium* of California and environs, showing the complex polyploid nature of the group. Some specific taxonomic conclusions are drawn, and two new taxa are described: *G. californicum* ssp. *luciense* of the Santa Lucia Mountains and *G. martirensense* of Baja California. A former variety is raised to specific rank as *G. cliftonsmithii*.

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## A FURTHER DESCRIPTION OF GOSSYPIUM TRILOBUM

PAUL A. FRYXELL

The exact nature of the Mexican plant originally described by De Candolle (1824) as *Ingenhouzia triloba* has never been clear, and considerable doubt has been expressed that it is, in fact, distinct from *Thurberia thespesioides* A. Gray. It is now possible to provide a more complete description and on such a basis to resolve the doubt by asserting that these two species are indeed distinct.

De Candolle's generic name was noted by Tidestrom (in Dayton, 1927) as a variant spelling of *Ingenhoussia* Dennst. 1818 and therefore to be illegitimate under Article 64. Irrespective of this rejection, however, it is generally accepted that both De Candolle's and Gray's plants belong in *Gossypium* L.

A third name, *G. lanceiforme* Miers, was subsequently published that is probably based on an isotype of De Candolle's species (Kearney, 1952). A historical summary of the taxonomic disposition of these three names is presented in Fig. 1.

Mauer's publication (1954) of three varietal names under *G. trilobum* contravenes Articles 26 and 36; the varietal names therefore are not validly published.

*Gossypium thurberi* Tod. (= *Thurberia thespesioides* A. Gray) is a plant, well represented in herbaria and in living collections, that occurs in southern Arizona, northern Sonora, and parts of western Chihuahua. It has been described and illustrated many times, notably among the

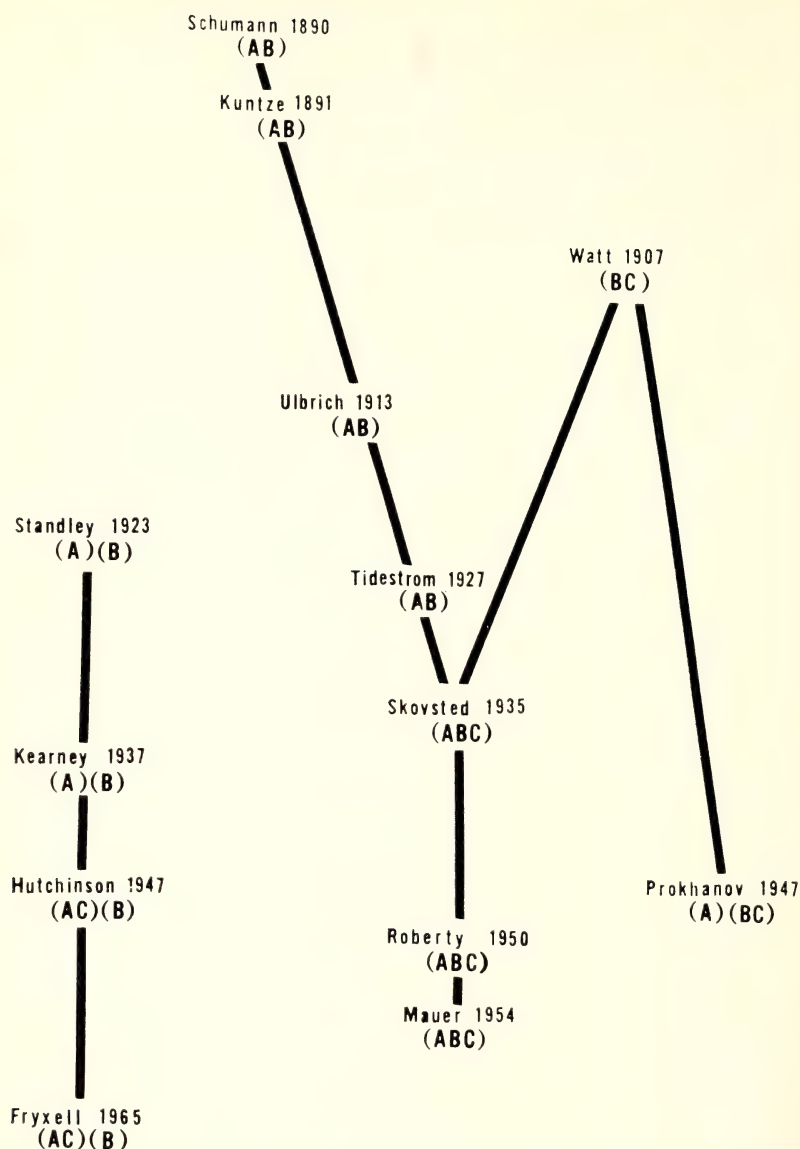


FIG. 1. Historical summary of views on the taxonomic disposition of: A. *Ingenhouzia triloba*, B. *Thurberia thespesioides*, and C. *Gossypium lanceiforme*.

fine drawings published by Saunders (1961). *Gossypium trilobum* (= *Ingenhouzia triloba* DC.), on the other hand, is poorly known; its existence is doubted by some and its distribution has been unclear to those who accept the species. It has never been available in culture.



FIG. 2. Geographic distribution of three species of *Gossypium*.

*Gossypium trilobum* has, moreover, been confused to some extent with still a third, relatively dissimilar species, *G. gossypoides* (Ulbr.) Standl. (= *Selera gossypoides* Ulbr), because of certain superficial similarities, although the distinction was made sufficiently and explicitly clear by Ulbrich (1913) in his description of *Selera gossypoides*. Roberty (1950), in fact, placed all three species in synonymy under *G. trilobum*. Standley (1923) recognized the distinctiveness of *G. gossypoides* and its position in *Gossypium*. Kearney (1937) underscored Standley's view and, except for Roberty (1950), has been followed by subsequent authors, including Hutchinson (1947) who, however, unfortunately cited two specimens under *G. gossypoides* that in fact represent *G. trilobum*. Hutchinson's citation of these specimens was quoted by Mauer (1954). Consequently, detailed comparisons involving *G. gossypoides* are also needed.

*Gossypium gossypoides* would be as poorly known as *G. trilobum* were it not that it has become available in culture from the seed collections of T. R. Richmond and C. W. Manning in 1946 and C. W. Manning and J. O. Ware in 1948. Brown and Menzel (1952a; 1952b)

TABLE 1. PRINCIPAL SIMILARITIES OF *G. trilobum* AND *G. thurberi* TOGETHER WITH PRINCIPAL FEATURES DISTINGUISHING THEM FROM *G. gossypoides*.

	<i>G. trilobum</i> or <i>G. thurberi</i>	<i>G. gossypoides</i>
Investiture of young twigs and petioles	Stellate, clusters <.1 mm, appearing lepidote, sparse, becoming glabrate	Soft-tomentose; hairs predominantly single, whitish, up to 0.5 mm
Twigs	Angled or ridged	Terete
Foliar nectaries	Present and functional	Vestigial
Involucral nectaries	Present and functional	Lacking
Bracts	1-2 cm long, distinct	3 cm long, connate prior to anthesis
Petal size	2-3 cm long	5 cm long
Petal spot	Small to vestigial	Large, covering half of petal
Filament color	Cream-colored	Dark red
Capsules	Non-flaring, persistent, with copious hairs on sutures	Flaring, abscising at base of peduncles, lacking suture hairs
Seeds	6-10 per loculus, 3-4 mm long, with sparse, minute pubescence, appearing black	1-4 per loculus, 5-7 mm long, with tan seed hairs up to 1 cm

TABLE 2. PRINCIPAL FEATURES DISTINGUISHING *G. trilobum* FROM *G. thurberi*.

	<i>G. trilobum</i>	<i>G. thurberi</i>
Leaf dissection	About $\frac{2}{3}$ dissected; sinuses acute; lobes ovate-acuminate, 2-3½ cm broad	About 9/10 dissected; sinuses rounded; lobes lanceolate-acuminate, 1-2 cm broad
Bracts	Cordate-acuminate, entire, 10-12 mm broad, 15-20 mm long	Subulate to cuneate, entire to (sometimes) toothed, 2-4 mm broad, 8-12 mm long
Calyx	With few to many (up to 12) irregular acuminate to aristate tips up to 4 mm long	Subtruncate, becoming undulate in fruit
Petal	Pale yellow	Cream-colored
Fruit	15-18 mm long, 10-12 mm broad, 8-10 seeds per loculus	10-15 mm long, 8-12 mm broad, 6-8 seeds per loculus

presented genetic and cytological data bearing on the position of this species in *Gossypium*. Subsequent studies (recently summarized by Saunders, 1961) indicate *G. thurberi* and *G. gossypoides* not to be closely related genetically.

Published knowledge of *G. trilobum* beyond the original description is nearly confined to the two plates and accompanying description published by Hutchinson (1947) and the few descriptive comments made by Kearney (1937). However, additional specimens of *G. trilobum* are now known that permit a full (and comparative) description of the species and an indication of its geographical distribution.

The following three species are compared in Tables 1 and 2 and their distribution is shown in Fig. 2. It is worth noting that the specimens of *G. trilobum* that are cited below fall within the relatively narrow altitudinal range of approximately 2500-5000 feet.



## NOMENCLATURE

GOSSYPIMUM THURBERI Todaro, Relaz. 120. 1877. *Thespesia thurberi* Alefeld, Bot. Zeit. 19:301. 1861, name illegitimate. *Thurberia thespesioides* A. Gray, Mem. Am. Acad. 5:308. 1855, not *Gossypium thespesioides* F. Muell. ex Tod. Relaz. 103. 1877. *Hibiscus ingenhousii* Kuntze, Rev. Gen. Pl. 1:69. 1891, pro parte. *Thurberia triloba* Tid. ex Dayt. Proc. Biol. Soc. Wash. 40:120. 1927, pro parte. *Gossypium trilobum* Skov. Jour. Genet. 31:288. 1935, pro parte.

Type. Cocospera-Barbasahui, Sonora, Mexico, *Thurber* 914 (US).

Representative specimens. CHIHUAHUA. SW Chihuahua, *Palmer* 269 (BM); Rio Bonito, *LeSueur* 792 (LL, TEX, UC, US). SONORA. 18 mi SE of Magdalena, *Wiggins* 7183 (ARIZ, DS, UC, US); Municipio de Nacore Chico, *Muller* 3653 (GH, LL, UC, US); Rio de Bavispe, *White* 4718 (ARIZ, GH, LL, MICH). ARIZONA. Santa Rita Mts., *Thornber* 186 (ARIZ, UC); Mule Mts., *Goodding* 3 (ARIZ); Rincon Mts., *Blumer* 3323 (ARIZ); near Bisbee, *Jones* 308 (ARIZ); Santa Catalina Mts. *Ginter* s. n. (ARIZ, UC).

GOSSYPIMUM TRILOBUM (Moç. & Sess. ex DC.) Skov. Jour. Genet. 31:288. 1935, pro parte; emend. Kearney. Am. Jour. Bot. 24:299. 1937. *Ingenhouzia triloba* Moç. & Sess. ex DC. Prodr. 1:474. 1824. *Hibiscus ingenhousii* Kuntze, Rev. Gen. Pl. 1:69. 1891, pro parte. *Gossypium lanceiforme* Miers ex Britt. Jour. Bot. 31:331. 1893. *Thurberia triloba* (Moç. & Sess. ex DC.) Tid. ex Dayt. Proc. Biol. Soc. Wash. 40:120. 1927, pro parte.

Type. Sessé and Moçño's specimen, kept in the Madrid herbarium and illustrated by Hutchinson (1947). Kearney (1952) notes that the type of *G. lanceiforme* may be a duplicate of the type of *Ingenhouzia triloba* DC.

Specimens examined. Guadalajara, Jalisco, *Rose* & *Hay* 6284 (GH, US); Concordia, Sinaloa, *de Ortega* 6033 (US); Acatitlán, Mexico, *Hinton* 5133 (GH, K); Zihuangio, Mexico, *Hinton* 9701 (MO, UC, US); Zitácuaro, Michoacán, *Hinton* 13253 (UC, US); km 15 Yautepac-Cuernavaca Road, Morelos, *Lundell* & *Lundell* 12498 (LL, UC, US); Sinaloa, *Mexia* 432 (MO).

In addition to the above specimens, Hutchinson's plate of the type and of the type of *G. lanceiforme* Miers ex Britt. (Hutchinson, 1947) have been consulted. On this basis the following description is presented.

Shrub, up to 4 m high, nigro-punctate, minutely stellate-puberulent becoming glabrate; twigs distinctly ridged. Leaves 3- (sometimes 5-) lobed, glabrate; lobes ovate-acuminate, up to 3½ cm broad; margin minutely ciliate. Petiole glabrate, ridged, nearly equaling lamina. Foliar nectary single, narrowly elongate, 1-2 mm. Stipules subulate to acuminate, ciliate, caducous. Fruiting branches many-jointed. Pedicels upright, ridged, glabrate, 1-1½ cm, surmounted by 3 nectaries. Bracts distinct, cordate, entire, acuminate, 10-12 mm broad, 15-20 mm long. Calyx prominently nigro-punctate with variable number (up to 12) of irregular acuminate to aristate tips up to 4 mm long. Petals punctate, pale yellow with small red basal spot. Androecial column pale-colored, punctate; filaments 2-3 mm. Style slender, exceeding androecium; stigma

clavate. Fruit glabrous, nigro-punctate, oblong, beaked, 15–18 mm long, 10–12 mm broad, generally 3-loculed; 8–10 seeds per loculus. Hairs on inner suture of capsule dense, tan, 2 mm long. Seeds angularly turbinate, 3–4 mm, black appearing striped because of minute tan pubescence.

*GOSSYPIUM GOSSYPIOIDES* (Ulbr.) Standl. Contr. U. S. Nat. Herb. 23:783. 1923. *Selera gossypoides* Ulbr. Verh. Bot. Ver. Prov. Brandenburg 55:51. 1913. *Gossypium trilobum* (Moç. & Sess. ex DC.) Skov. emend. Rob. Candollea 13:30. 1950, pro parte.

Type. Im Gebüsch, San Bartolo Yautepec, Oaxaca, C. & E. Seler 1700 (location of specimen not ascertained).

Specimens examined. Cuicatlan, Oaxaca, *Nelson 1704* (GH, US); *Conzatti 3874* (US); cultivated plants grown from collections from 83 miles S of Oaxaca, *Richmond & Manning s. n.* (ARIZ, TAES).

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## NEW TAXA IN THE GENUS *MONARDA* (LABIATAE)

RAINER W. SCORA

During a biosystematic study of the genus *Monarda* (Scora, 1964) it became necessary to describe the following new taxa and to make one new combination.

***Monarda dressleri*** Scora, sp. nov. Herba perennis, gracilis erecta, altitudine 60–80 cm, pilis minutis puberulis, simplex vel ramosa; foliorum laminis lanceolatis, 23–45 mm longis, 11–21 mm latis, in apicem acuminatis, in basem obtusis vel rotundis, marginibus subserratis, supra pubescentibus pilis minutis appressis, subtus pubescentibus pilis minutis canescentibus, petiolis 4–8 mm longis; bracteis paucis foliaceis, ovatis-lanceolatis, puniceis, glomerulis 20–30 mm latis, paucifloris, monocephalis; calycum tubis 8–13 mm longis, 13 venis, pubescentibus pilis minutis canescentibus, in ore dense hirsutis pilis 0.5 mm longis, lobis acutissimis 1.5–2.0 mm longis, glandulis elevatis; collarum coccinearum purpurearum saepius immaculatarum, tubis 25–30 mm longis, labia superiore 9–12 mm longa; staminibus inter fauces corollae 3–5 mm insertis; stylo glabro.

Type. 40 km W of Aldama, Tamaulipas, Mexico, *Dressler 1851* (MEXU 47528—holotype, MICH, MO).

*Monarda dressleri* is a member of the subgenus *Monarda* and is named for R. L. Dressler who has collected extensively in Tamaulipas.

*Monarda dressleri* has the habit of the *M. fistulosa* L. complex, but its corolla resembles more closely those of the larger flowered Mexican species of *M. pringlei* Fernald and *M. bartlettii* Standley. It differs from all the other Mexican species in the subgenus *Monarda* in its corolla color and its larger pollen size of about 20 per cent in diameter. It differs from its near relative *M. pringlei* in that it inhabits oak forests, has an evenly expanded corolla with a very pubescent upper lip and a stamen attachment of 3–5 mm depth in the corolla throat, while *M. pringlei* occurs on calcareous soil, has an abruptly expanded corolla with a slightly pubescent upper lip and a stamen attachment 6–7 mm deep. *Monarda dressleri* differs from the related *M. bartlettii* in leaf pubescence, in the narrower and shorter leaves, its stamen attachment and in the indument of the calyx lobes. *Monarda dressleri* is distinguished from *M. eplingiana* Standley in that the leaves are not membranaceous and the calyx lobes are twice as long and beset with stalked glands, while in *M. eplingiana* the calyx lobes are non-glandular. From *M. malloyi* Gilg it differs in that the latter grows near the borders of tropical forests, is of a more robust habit, has shorter calyx lobes which are non-glandular.

MONARDA CITRIODORA Cerv. ex Lag. The varieties and subspecies of *M. citriodora* may be identified with the aid of the following key.

Bracts subtending glomerules lanceolate to linear-lanceolate, gradually acuminate to a spinose bristle, not more than 4 mm wide, strongly reflexed from base.

ssp. *austromontana*

Bracts subtending glomerules oblong, abruptly acuminate to a spine-like bristle, or attenuate, commonly more than 4 mm wide, spreading horizontally, or forming a cup-like involucre, but not reflexed from base.

Foliage light green; inner bracts subtending glomerules densely pubescent with short white or purple hairs; the apex abruptly acuminate, bracts reflexed from middle and thus forming a cup-shaped involucre.

Leaves 25–60 mm long, 8–12 mm wide; bracts mostly wider than 5 mm; calyx tubes 7–14 mm long; unexpanded portion of corolla tube 7–10 mm long, the expanded portion 4–6 mm long; apex of upper corolla lip with 1 mm long hairs.....ssp. *citriodora* var. *citriodora*

Leaves (12)–20–35–(40) mm long, (3)–5–10–(14) mm wide; bracts not wider than 5 mm; calyx tubes 5–7 mm long; calyx lobes about 2–3 mm long; unexpanded portion of corolla tube 6–7 mm long, expanded portion 2–4 mm long; apex of upper corolla lip mainly glabrate.

ssp. *citriodora* var. *parva*

Foliage dark green; inner bracts subtending glomerules glabrate or sparingly pubescent with short hairs; the apex attenuate, spreading horizontally and not forming a cup-like involucre; calyx lobes rarely ciliate; upper half of corolla lip pubescent with 1–2 mm long hairs.

ssp. *citriodora* var. *attenuata*

MONARDA CITRIODORA Cerv. ex Lag. ssp. *austromontana* (Epling) Scora, com. nov. *M. austromontana* Epling, Madroño 3:29. 1935.

MONARDA CITRIODORA Cerv. ex Lag. ssp. CITRIODORA var. *parva* Scora, var. nov. Herba annua, erecta, altitudine 20–50 cm, caulis simplicis, pills minutibus puberulis; foliorum laminis lanceolatis vel oblongis, maximis (12)–20–35–(40) mm longis, (3)–5–10–(14) mm latis, in apicem abrupte acutis, in basem acuminatis vel obtusis, marginibus serratis vel subserratis, supra scabratis, subtus hirsutis pilis minutis; petiolis 2–8 mm longis; glomerulis verticillastris; bracteis exterioribus foliaceis, mediis oblongis, erectis, in apicem abrupte acuminatis et aristatis, pagina adaxilia dense pubescente pilis minutis, basis marginibus ciliatis, calycum tubis 5–7 mm longis, 15 venis, lobis aristatis 2–3 mm longis; corollis 14–19 mm longis, abrupte dilatatis; labia superiore 5–7 mm longa, incisa 0.5–1.0 mm, glabrata, rarissime puberula pilis 0.5–1.0 mm longis; labia inferiore 7–8 mm longa, lobo mediano 1–3 mm longo; staminibus glabris, inter fauces 1–3 mm insertis; stylo glabro; chromosomis  $n = 9$ ; oleis  $\alpha$ -pineno,  $\gamma$ -terpineno, heptanone, nonanale, thymole et carvacrole satis inhaerentibus.

Type. Near Sinton, San Patricio Co., Texas, *C. M. Rowell* 4977 (WWF).

Specimens examined. Texas. Cameron Co.: Brownsville, *Tharp* 1196 (US); *Ferris & Duncan* 3131 (MO); Los Fresnos, *Wolff* 2368 (TAES). Hidalgo Co.: San Juan, *Clover* 5 (NY). San Patricio Co.: Welder Wildlife Refuge, *Scora* 2222 (MICH); E of Sinton, *Powell* 4977 (WWF); *Box* 148 (WWF).



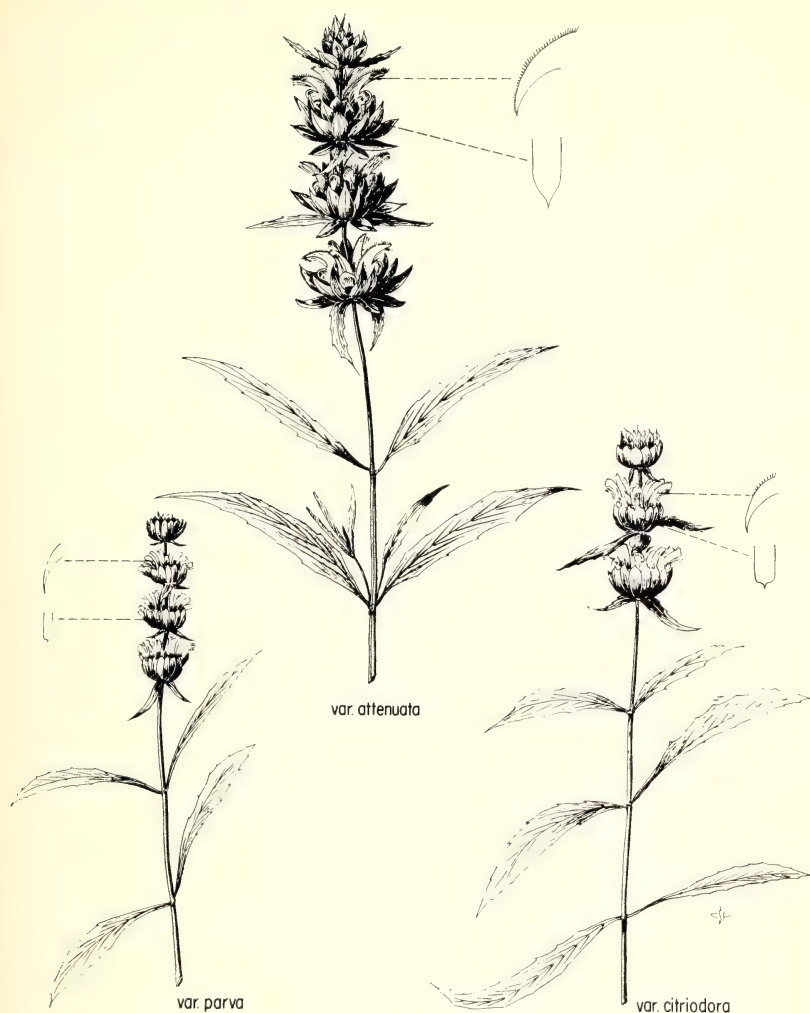


FIG. 1. Varieties of *M. citriodora* ssp. *citriodora*.

This variety is the "fairly well-defined but unnamed form in southern Texas" of McClintock and Epling (1942).

MONARDA CITRIODORA Cerv. ex Lag. ssp. CITRIODORA var. **attenuata** Scora, var. nov. Herba annua, erecta, altitudine 30–60 cm, caulibus virgatis, pilis minutibus puberulis; foliorum laminis lanceolatis interdum oblongis, maximis 30–65 mm longis, 4–13 mm latis, in apicem acutis vel obtusis, in basem angustatis, marginibus serratis, supra scabratis, subtus puberulis pilis minutis; petiolis 4–28 mm longis; glomerulis verticillastris; bracteis exterioribus foliaceis longioribus, mediis oblongis

rarius lanceolatis, in apicem attenuatis, pagina adaxilia glabrata, rarissime puberula pilis minutis albidis, basis marginibus ciliatis, calycum tubis 9–13 mm longis, 15 venis, lobis aristatis 3–7 mm longis; corollis roseis saepius immaculatis, 21–30 mm longis, abrupte dilatatis; labia superiore 9–12 mm longa, incisa 1.0–1.5 mm, pubescentium pilis 1–2 mm longis; labia inferiore 12–17 mm longa, lobo mediano 4–6 mm longo; staminibus glabris, inter fauces 2–4 mm insertis; stylo glabro; chromosomis  $n = 9$ ; oleis  $\alpha$ -pineno,  $\gamma$ -terpineno, heptanone, nonanale, thymole et carvacrole satis inhaerentibus.

Type. Near Musquiz, Coahuila, Mexico, *R. W. Scora 2340* (MICH—holotype, UCR).

Specimens examined. Mexico. Coahuila: Musquiz, *Marsh 155* (F); Sierra del Carmen, Canon de Sentenela, *Wyend & Mueller 524* (MO).

*Monarda citriodora* var. *attenuata* (fig. 1) is distinguished from var. *citriodora* (fig. 1) mainly by its more horizontally spreading bracts subtending the glomerules, their nearly glabrous adaxialbract surfaces, green coloration and the more attenuate bract apices. The calyx lobes have few or no lateral hairs and the corolla dimensions are larger than those of var. *citriodora*. Variety *parva* (fig. 1.) differs from var. *attenuata* in having the bracts subtending the glomerules cupped and not horizontally spreading, in their pubescence, whitish coloration, abrupt acuminate bract apices, shorter calyx lobes and smaller overall dimensions of stem, foliage, calyx tubes and corollas. It differs from var. *citriodora* in the almost always glabrous upper corolla lip, and the reduced corolla size, calyx tube, calyx lobe, number of glomerules, leaf size and plant height. Living cultures which were grown for several generations in the greenhouses and growth chambers at the University of Michigan Botanical Gardens to find if these differences were genetically fixed or mere environmental variations showed, that all these differences remained although internode length increased in var. *parva* when grown under greenhouse conditions.

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#### LITERATURE CITED

- McCLINTOCK, E. and C. EPLING. 1942. A review of the genus *Monarda* (Labiatae). Univ. Calif. Publ. Bot. 20:147–194.  
SCORA, R. W. 1964. Interspecific relationships in the genus *Monarda* (Labiatae). Ph.D. dissertation (unpublished). Univ. of Michigan, Ann Arbor.

#### DOCUMENTED CHROMOSOME NUMBERS OF PLANTS

(See Madroño 9:257–258. 1949; 17:255. 1964)

*Aesculus californica* (Spach) Nutt.  $n = 20$ . California, Alameda Co., Univ. Calif. campus. *R. Lloyd 2633*, UC. Counted by R. Ornduff and R. Lloyd.

- A. sylvatica* Bartr. **n** = **20**. North Carolina, Durham Co., Duke Forest. *R. Ornduff* 6377, DUKE. Counted by R. Ornduff and R. Lloyd.
- Allotropa virgata* T. & G. ex Gray. **2n** = **26**<sub>II</sub>. California, Humboldt Co., near Hawkins Bar. *D. E. Anderson* 2447, UC.
- Alopecurus aequalis* Sobol. **2n** = **7**<sub>II</sub>. Utah, Summit Co. *D. E. Anderson* 2790, UC.
- Anthoxanthum odoratum* L. **2n** = **20**. California, Humboldt Co., Arcata. *D. L. Gray* 64001, UC.
- Aristolochia californica* Torr. **2n** = **16**<sub>II</sub>. California, Yuba Co. *C. B. Wolf* 1741 (progeny), RSA. Counted by P. H. Raven. Gregory (Am. Jour. Bot. 43:111. 1956) reported **2n** = **28** in this species from material "from Rancho Santa Ana Botanic Garden" (Gregory, pers. comm.) and therefore this is possibly the same strain.
- Bidens pilosa* L. var. *radiata* Sch.-Bip. **n** = **24**. Florida, Charlotte Co. *E. B. Smith* 530, KANU.
- Bocconia frutescens* L. **n** = **20**. California, San Francisco Co., Strybing Arboretum, *W. R. Ernst* 709, DS. Cultivated; Alameda Co., Univ. Calif. *W. R. Ernst* 732, DS (progeny from Peru, Machu Picchu, *West* 6472, UC).
- Brodiaea appendiculata* Hoover. **n** = **6**. California, Amador Co., Ione. *T. F. Niehaus* 515, UC.
- B. californica* var. *leptandra* (Greene) Hoover. **2** = **12**. California, Napa Co., Mt. St. Helena. *R. F. Hoover* 5904, UC. Counted by *T. F. Niehaus*. Cultivated UCBG 55.926.
- B. clementina* (Hoover) Munz. **2n** = **16**. California, Los Angeles Co., San Clemente I. *T. F. Niehaus* 376, UC.
- B. coronaria* (Salisb.) Engler. **2n** = **24**. California, Sacramento Co., near Ione. *T. F. Niehaus* 512, UC.
- B. coronaria* var. *macropoda* (Torr.) Hoover. **2n** = **36**. California, Marin Co., Drakes Beach, *T. F. Niehaus* 535, UC.
- B. coronaria* var. *rosea* (Greene) Hoover. **2n** = **12**. California, Lake Co., Indian Valley, *T. F. Niehaus* 556, UC.
- B. dudleyi* (Hoover) Munz. **n** = **8**. California, Tulare Co., Summit Lake, *T. F. Niehaus* 611, UC.
- B. elegans* Hoover. **n** = **8**. California, Nevada Co., Grass Valley. *T. F. Niehaus* 128, UC.
- B. filifolia* Wats. **2n** = **32**. California, Los Angeles Co., San Clemente I. *T. F. Niehaus* 397, UC.
- B. gracilis* Wats. **n** = **8**. California, Plumas Co., Spanish Peak, *T. F. Niehaus* 587, UC.
- B. hyacinthina* (Lindl.) Baker. **n** = **28**. California, Nevada Co., Bear Valley. *T. F. Niehaus* 549, UC; **n** = **35**. California, Yuba Co., near Marysville, *T. F. Niehaus* 220, UC.
- B. hyacinthina* var. *greenii* (Hoover) Munz. **2n** = **16**. California, Butte Co., Table Mt., *T. F. Niehaus* 372, UC.
- B. jolonensis* Eastw. **2n** = **12**. California, Monterey Co., Jolon. *T. F. Niehaus* 511, UC.
- B. lutea* var. *anilina* (Greene) Munz. **n** = **20**. California, Sierra Co., Gold Lake. *T. F. Niehaus* 586, UC.
- B. pallida* Hoover. **n** = **6**. California, Tuolumne Co., Chinese Camp. *T. F. Niehaus* & *W. Savage* 526. Counted by *T. F. Niehaus*.
- Carpentaria californica* Torr. **n** = **10**. California, Santa Clara Co., Carnegie Institution. *W. R. Ernst* 733, DS. Cultivated.
- Cathcartia villosa* Hook. f. **n** = **16**. California, Alameda Co., Univ. Calif. *W. R. Ernst* 731, DS. Cultivated.
- Chelidonium majus* L. **2n** = **12**. Connecticut, New Haven. *K. Chambers* 1151, DS.

Counted by W. R. Ernst. Mitosis in anther.

- Chrysopsis aspera* Shuttlew. **n** = 18. Alabama, Coosa Co. *E. B. Smith* 475, KANU.
- Chrysosplenium glechomifolium* Nutt. **2n** = 9<sub>II</sub>. California, Humboldt Co., near Arcata. *D. E. Anderson* 2975, UC.
- Clematis crispa* L. **n** = 8. South Carolina, Berkeley Co., near Monck's Corner. *R. Ornduff* 6412, UC.
- Clethra lanata* Mart. & Gal. **2** = 8<sub>II</sub>. Mexico, Chiapas, Municipio of Tenejapa. *D. E. Breedlove* 6947, DS, F. Counted by D. W. Kyhos.
- Corydalis lutea* DC. **n** = 28. California. Santa Clara Co., Palo Alto. *W. R. Ernst* 575, DS. Cultivated.
- Dicentra chrysantha* (H. & A.) Walp. **n** = 12. California, San Benito Co., near Idria. *W. R. Ernst* 521, DS; Fresno Co., Los Gatos Creek road near San Benito Co. line. *W. R. Ernst* 530, DS. Some cells with an extra fragment.
- D. formosa* (Haw.) Walp. **n** = 8. California, Tuolumne Co., Crocker Ridge. *W. R. Ernst* 764, DS.
- D. nevadensis* Eastw. **n** = 8. California. Tulare Co., near Big Meadow Guard Station. *W. R. Ernst* 570, DS.
- D. ochroleuca* Engelm. **n** = 16. California, Los Angeles Co., Mulholland Drive. *P. H. Raven* 14859, DS. Counted by W. R. Ernst.
- D. spectabilis* (L.) Lem. **n** = 8. California, Santa Clara Co., Stanford Univ. *W. R. Ernst* 488, DS. Cultivated.
- Drymaria debilis* Brandege. **2n** = 22<sub>II</sub>. Mexico, Baja California, Bahía de la Concepción. *I. L. Wiggins* 19001, DS. Counted by D. W. Kyhos.
- Erigeron quercifolius* Lam. **n** = 9. South Carolina, Berkeley Co., near Monck's Corner. *R. Ornduff* 6415, UC.
- E. inflatum* T. & F. var. *inflatum*. **n** = 16. Clark Co., near Las Vegas. *A. Cronquist* 9919, NY, UTC. Counted by J. L. Reveal.
- E. maculatum* Heller. **n** = 20. California, Mono Co., near Old Benton. *J. L. Reveal* & *J. L. Reveal* 551, UTC. Nevada, Clark Co., near Searchlight. *A. Cronquist* 9974, NY, UTC; Humboldt Co., Pine Forest Range, *A. H. Holmgren* & *J. L. Reveal* 1325, NY, UTC. Counted by J. L. Reveal.
- E. nudum* Dougl. ex Benth. var. *pubiflorum* Benth. **n** = 20. California, Modoc Co., Warner Range. *A. H. Holmgren* & *J. L. Reveal* 1717, NY, UTC. Counted by J. L. Reveal.
- E. ovalifolium* Nutt. var. *nivale* (Canby) Jones. **n** = 20. California, Mono Co., Sonora Pass. *J. L. Reveal* & *J. L. Reveal* 492, UTC. Nevada, Nye Co., Toquima Range, *J. L. Reveal* 629, NY, UTC. Counted by J. L. Reveal.
- E. ovalifolium* Nutt. var. *ochroleucum* (Small) Peck. **n** = 20. Nevada, Humboldt Co., Pine Forest Range. *A. H. Holmgren* & *J. L. Reveal* 1263, NY, UTC. Counted by J. L. Reveal.
- E. ovalifolium* Nutt. var. *orthocaulon* (Small) Hitchc. **n** = 20. Idaho, Butte Co., near Big Lost River. *A. H. Holmgren* & *J. L. Reveal* 825, NY, UTC. Nevada, Humboldt Co., Pine Forest Range. *A. H. Holmgren* & *J. L. Reveal* 896, NY, UTC. Counted by J. L. Reveal.
- E. pusillum* T. & G. **n** = 16. California, San Bernardino Co., near Needles. *A. Cronquist* 9912, NY, UTC. Counted by J. L. Reveal.
- E. reniforme* T. & F. **n** = 16. Arizona, Mohave Co., near Kingman. *A. Cronquist* 9945, NY, UTC. Counted by J. L. Reveal.
- E. sphaerocephalum* Dougl. ex Benth. var. *halimioides* (Gand.) Stokes. **n** = 20. Nevada, Humboldt Co., Pine Forest Range. *A. H. Holmgren* & *J. L. Reveal* 1237, NY, UTC. Counted by J. L. Reveal.
- E. trichopes* Torr. ssp. *minor* (Benth.) Stokes. **n** = 16. Nevada, Nye Co., Mercury. *A. Cronquist* 9917, NY, UTC. Counted by J. L. Reveal.
- Eriogonum umbellatum* Torr. ssp. *polyanthum* (Benth.) Stokes. **n** = 40. Nevada, Humboldt Co., Pine Forest Range. *A. H. Holmgren* & *J. L. Reveal* 1225, NY, UTC. Counted by J. L. Reveal.



- Eupatorium album* L. **n** = 10. South Carolina, Richland Co. *E. B. Smith* 504, KANU.
- Fritillaria atropurpurea* Nutt. **n** = 12. Utah, Cache Co., Green Canyon. *J. L. Reveal* & *P. J. Bottino* 711, UTC. Counted by *P. J. Bottino*.
- Helenium decurrens* (Macbr.) Moldenke. **n** = 20. South Carolina, Jasper Co. *E. B. Smith* 523, KANU.
- Helianthus angustifolius* L. **n** = 17. Louisiana, Vernon Parish. *E. B. Smith* 545, KANU.
- Heterotheca subaxillaris* (Lam.) Britt. & Rusby. **n** = 9. Florida, Okeechobee Co. *E. B. Smith* 531, KANU.
- Hierochloe occidentalis* Buckl. **2n** = 21<sub>II</sub>. California, Humboldt Co., near Arcata. *D. E. Anderson* 2925, UC.
- Hilaria jamesii* (Torr.) Benth. **2n** = 18<sub>II</sub>. Colorado, Mesa Co., Colorado National Monument. *D. E. Anderson* 7288, UC.
- Houstonia caerulea* L. **n** = 16. North Carolina, Durham Co., Duke University. *W. R. Anderson* s. n., UC. Counted by *R. Ornduff*.
- H. serpyllifolia* Michx. **n** = 8. South Carolina, Oconee Co., Camp Jocassee. *R. Ornduff* 6382, UC.
- Illicium floridanum* Ellis. **n** = 13. Louisiana, Washington Parish. *D. E. Stone* 1357, NO. **2n** = 26. Mississippi, Hancock Co. *D. E. Stone* 1522, DUKE.
- I. parviflorum* Michx. ex Vent. **n** = 14. Florida, Gainesville. *D. E. Stone* 1422, DUKE. Cultivated.
- Marshallia graminifolia* (Walt.) Small. **n** = 9. South Carolina, Georgetown Co. *E. B. Smith* 516, KANU.
- Meconopsis betonicifolia* Franch. **n** = 40. California, Mendocino Co., Fort Bragg. *W. R. Ernst* 738, DS. This is "var. *baileyi*" with pubescent fruits. Cultivated.
- M. cambrica* (L.) Vig. **n** = 28. California, Berkeley, Univ. Calif. *W. R. Ernst* 730, DS. Cultivated.
- M. ? paniculata* (D. Don) Prain. **n** = 28. California, San Francisco Co., Strybing Arboretum. *W. R. Ernst* 734, DS. Corollas yellow. Cultivated.
- Melianthus major*. **2n** = 18<sub>II</sub>. California, Humboldt Co., Arcata. *D. E. Anderson* 2917, UC. Cultivated.
- Orthocarpus castillejooides* Benth. var. *humboldtensis* Keck. **2n** = 12<sub>II</sub>. California, Humboldt Co., salt marshes of Humboldt Bay. *D. E. Anderson* 2973, UC.
- Palafoxia integrifolia* T. & G. **n** = 10. Texas, Fayette Co. *E. B. Smith* 552, KANU.
- P. sphacelata* (Nutt.) Cory. **n** = 12. Texas, Bastrop Co. *E. B. Smith* 555, KANU.
- Papaver alpinum* L. **n** = 7. California, Santa Clara Co., Stanford Univ. *W. R. Ernst* 551, DS. Pubescent and glabrous plants studied. Cultivated.
- P. atlanticum* Ball. **n** = 7. California, Santa Clara Co., Stanford Univ. *W. R. Ernst* 553, DS. Some cells with a tetravalent figure. Cultivated.
- P. bracteatum* Lindl. **n** = 21. California, Santa Clara Co., Stanford Univ. *W. R. Ernst* 729B, DS. Most flowers subtended by a pair of large foliose bracts. Cultivated.
- P. nudicaule* L. **n** = 14. California, Santa Clara Co., Stanford Univ. *W. R. Ernst* 552, DS. Common Iceland Poppy of nursery trade. Cultivated.
- P. rhoeas* L. **n** = 7. California, Santa Clara Co., Stanford Univ. *W. R. Ernst* 599, DS. Common single and double forms of Shirley poppy. Cultivated.
- P. somniferum* L. **n** = 11. California, Santa Clara Co., Stanford Univ. *W. R. Ernst* 566A, DS. Common opium poppy, occasionally with a few hairs on peduncles and petioles. Cultivated; *W. R. Ernst* 566B, DS. Common multiple-petaled or double opium poppy. Cultivated.
- Plantago erecta* Morris. **2n** = 10<sub>II</sub>. California, Ventura Co., Santa Monica Mts. *P. H. Raven* 14866, LA. **2n** = 20. California, Humboldt Co., near Samoa. *D. E. Breedlove* 3046 (progeny), DAV; Los Angeles Co., Santa Catalina I. *P. H. Raven* (progeny), RSA; Santa Catalina I., Middle Ranch, *P. H. Raven* 17841 (progeny), DAV; San Clemente I. *P. H. Raven* 17227 (progeny), DAV, RSA. (*P. erecta* ssp.

- rigidior* Pilger).  $2n = 42$ . California, Santa Barbara Co., near Lompoc, *P. H. Raven 15511* (progeny), DAV. No evident correlation was found between chromosome number and either morphology or pollen size in these collections, which appear to span the range of variation in this species. All collections studied were autogamous, in contrast to the allogamous but similar *P. insularis* Eastw. Counted by D. M. Moore.
- P. insularis* Eastw.  $2n = 8$ . California, San Bernardino Co., near Barstow. *D. M. Moore 422*, DAV.
- Pleuropogon refractus* (Gray) Benth. ex Vasey.  $2n = 18_{II}$ . California, Humboldt Co., near Arcata. *D. E. Anderson 2404b*, UC.
- Porophyllum tridentatum* Wats. var. *crassifolium* Johnston.  $n = 15$ . Mexico, Baja California, San Bruno. *A. Carter & J. Reese 4538*, UC, KANU. Counted by R. R. Johnson.
- Primula maguirei* Williams  $n = 22$ . Utah, Cache Co., Logan Canyon. *J. L. Reveal & P. J. Bottino 710*, UTC.
- Schisandra glabra* (Brickell) Rehder.  $2n = 28$ . Florida, Liberty Co., *D. Demaree*, April 6, 1964, DUKE. Counted by D. E. Stone.
- Sidalcea malachroides* (H. & A.) Gray.  $2n = 10_{II}$ . California, Humboldt Co., near Arcata. *D. E. Anderson 2502*, UC.
- Solanum brachystachys* Mart. & Gal.  $2n = 12_{II}$ . Mexico, Chiapas, Municipio of Chamula. *D. E. Breedlove 7060*, DS. Counted by D. W. Kyhos.
- Tolmiea menziesii* (Pursh) T. & G.  $2n = 14_{II}$ . California, Humboldt Co., near Arcata. *D. E. Anderson & B. D. Rogers 1564*, UC. Counted by B. D. Rogers.

## REVIEWS

*A Selected Guide to the Literature on the Flowering Plants of Mexico*. By IDA KAPLAN LANGMAN. 1015 pp. University of Pennsylvania Press, Philadelphia, 1964. \$25.00.

The publication of this annotated bibliography culminates more than 20 years of dedicated labor. The breadth of Mrs. Langman's research on the literature of Mexican botany is indicated to some extent by the journals and the bibliographic titles cited in the preliminary materials and by the list of libraries which she consulted. In order to obtain references to local material that might not have found its way to the larger libraries, Mrs. Langman visited libraries in 27 states of Mexico, so that here we have an invaluable tool for all having an interest in any aspect of Mexican botany from the time of the Conquistadores to the present. The vicissitudes of publishing evidently made impossible the last minute inclusions of references to the most important taxonomic contribution to our knowledge of the flora of northwestern Mexico, I. L. Wiggins, *Flora of the Sonoran Desert* (Stanford University Press, 1964).

Of the 1015 pages, 792 are devoted to an alphabetical compilation of author citations. The user should refer to Mrs. Langman's remarks (p. 12) regarding the difficulties encountered in citing authors' names, especially the Latin American "trinomials."

The 156 pages of Index (four columns to a page) immeasurably increase the value of the Bibliography, for the author's labor has forestalled ours. Familiarity with its organization will enable knowledgeable researchers to by-pass several of the reference steps. Otherwise, a step-by-step search for information about *ĵicama* would lead the reader from *ĵicama* to the genera *Cacara*, *Dolichos*, and *Pachyrrhizus*, each of which in turn refers him to "Leguminosae." Under this family the genera are listed in alphabetical order. Under the genera are various subject headings, and, finally, the desired author references to the main part of the Bibliography, q.v. A typographically understandable but unfortunate structural difficulty in the Index is the minimal indentation of the first subheadings. This, coupled with the fact that the main heading (when a subject is carried from column to column) is

included only on the first of the four columns of each page, sometimes makes it difficult to find the desired entry in the Index. This problem is amply illustrated by perusal of the several pages of references to the Cactaceae.

Ida Langman, the institutions and grantors which supported her work, and the University of Pennsylvania Press deserve our thanks and congratulations for bringing this work to fruition. It is a "must" for all libraries having any interest in Mexico, as well as for all people concerned with any aspect of the plants of the area. Anyone using the volume should first turn to p. 9 and lighten his day by reading "Random Thoughts on Bibliographies."—ANNETTA CARTER, Department of Botany, University of California, Berkeley.

*The Vascular Plants of Monterey County, California.* By BEATRICE F. HOWITT and JOHN THOMAS HOWELL. The Wasmann Journal of Biology 22(1):ii+1—184. 1964. Published by the University of San Francisco. Available from the California Academy of Sciences, Golden Gate Park, San Francisco, California 94118. \$2.75.

This work is a welcome addition to the floras and annotated checklists of the vascular plants of central California. Monterey County, the area covered by this annotated catalogue, is about 3324 square miles in extent and is located along the California coast south of San Francisco. The vascular flora is made up of 119 families, 539 genera, 1713 specific and infraspecific categories. Of these, 291 are introduced and 37 are endemic. Some 302 species have either their northern or southern limits of distribution in the Coast Ranges in Monterey County. For the Santa Cruz Mountains immediately to the north, the corresponding figure is 242 and for Marin County to the north of San Francisco the figure is 123. Monterey County then would appear to have special significance in the phytogeography of the California Coast Ranges.

The County has been divided into eight major sections based on terrain, and these are discussed, outlined on a map, and the conspicuous plants in them listed. These sections and specific localities within them are used in the catalogue to indicate distribution within the County. There is no discussion of the plant communities, characteristic assemblages of plants, as such. The short section by Oliver E. Bowen outlines the main features of the geology. The arrangement of families follows that of *A California Flora*; common names are listed; specific names are capitalized; and neither keys nor descriptions are included. There are 22 text figures and a frontispiece which depict various vegetation types. Undue emphasis has been given to type localities. Information of this sort for each species adds little to local floristic works except length. More often than not, the geographical location of a type locality is a matter of historical accident rather than of biological significance. It does not follow from the fact that one fifth of the plants in Monterey County have their type locality there that it is (p. 24) ". . . one of the richest and most important research areas for field studies in systematic botany in western America."

Hopefully this work will stimulate local groups and individuals to guard and preserve the diversity of species in this area, an area known to many throughout the world because of the Monterey Cypress and the Monterey Pine.—JOHN H. THOMAS, Dudley Herbarium, Stanford University.

## NOTES AND NEWS

**LABELS FOR HERBARIUM SPECIMENS.**—With relatively few exceptions labels accompanying herbarium specimens are unsatisfactory. Many include only the sketchiest data as to locality; most indicate nothing about habitat, soil type, slope, exposure, associated plants, flower color, etc.; and many are of a very poor quality paper. Often this is understandable. It takes time and/or money to have adequate labels typed or printed. Advances in the art of photo-offset printing have, however, made it possible to produce labels at a reasonable cost, less in fact than it costs to have them typed. At Stanford University, we now routinely have labels made by the offset method even when only 20–25 copies of any particular one are needed.



Sample labels are typed, and six of them pasted on a standard size sheet of typing paper. These are then photographed by the University photographic service with an Itek camera on an Itek photodirect master. Up to 1000 copies can be made from one master. Should more be required, a metal offset plate can be made with the capacity of producing over 5000 copies. Any kind of paper, including 100% rag, and even 90 lb. card stock, can be used with either the photodirect master or the metal offset plate. The cost of the photodirect master (in our experience) is \$1.00. A press run of 100 copies is \$1.10; that for 1000 copies is down to \$4.20. A good quality, 100% rag paper is about \$7.50 per ream. Assuming that one needs 100 copies of each of six different labels, the cost per individual label is slightly over one-half a cent. The advantages of this method are obvious.—JOHN H. THOMAS, Dudley Herbarium, Stanford University.

THE HERBARIUM OF HOWARD E. McMINN.—During his teaching and research career from 1918 to 1957, the late Professor Howard E. McMinn built up, in the Biology Department of Mills College, a significant herbarium of native woody plants of California as well as collections of introduced woody ornamentals and allergenic plants of California. A few months ago, in order to facilitate the availability of McMinn's voucher specimens to interested botanists, his native plant collections were transferred to the Herbarium of the University of California at Berkeley. These specimens (approximately 4000) served as the basis for McMinn's following important books and monographs: H. E. McMinn and E. Maino, 1937, *An Illustrated Manual of Pacific Coast Trees*, Univ. Calif. Press, Berkeley; H. E. McMinn, 1939, *An Illustrated Manual of California Shrubs*, Univ. of Calif. Press; M. van Rensselaer and H. E. McMinn, 1942, *Ceanothus*, Santa Barbara Botanic Garden, Santa Barbara, Calif.; H. E. McMinn, 1951, *Studies in the Genus Diplacus, Scrophulariaceae*, Madroño 11:33–128. McMinn's specimens will be undergoing processing at the University of California shortly and should be available for study by the end of 1966. Thereafter, requests for borrowing them should be addressed directly to the Director of the University of California Herbarium, University of California, Berkeley, California.

McMinn's collections of "Introduced Woody Plants of California" and "Wind Pollinated Plants of California" are kept in the Biology Department of Mills College as reference and teaching material in Botany classes. This portion of McMinn's herbarium consists of approximately 2000 specimens of ornamental plants and over 1000 allergenic plants. Most of the voucher specimens that have been utilized in the publication of the following two books are maintained in this herbarium: H. E. McMinn, 1919, *A Manual of Trees, Shrubs and Vines of Mills College Campus*, H. S. Crocker Co., Inc., San Francisco and Oakland; E. Graham and H. E. McMinn, 1941, *Ornamental Shrubs and Woody Vines of the Pacific Coast*, Gillick Press, Berkeley, Calif. These specimens are filed according to generic names among which *Acacia*, *Acer*, *Berberis*, *Callistemon*, *Cotoneaster*, *Erica*, *Escalonia*, *Eucalyptus*, *Fraxinus*, *Ilex*, *Leptospermum*, *Melaleuca*, *Pittosporum*, *Pyra-cantha* and *Tilia* are particularly well-represented. Previous arrangement is necessary for those interested in studying these specimens.—BAKI KASAPLIGIL, Department of Biology, Mills College, Oakland, Calif.

The following publications are of interest:

*The Genus Lithophragma*. By ROY L. TAYLOR. University of California Publications in Botany 37:1–122. University of California Press, Berkeley and Los Angeles. 1965. \$3.00.

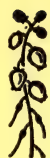
*Orchids, Care and Growth*. By MICHEL PAUL. Universe Books Inc., 381 Park Ave. S., New York 10016. 135 pp. 1965. Paper, \$1.95; hardcover, \$2.75.

*Drawings of British Plants*. By STELLA ROSS-CRAIG. Part XVIII. Boraginaceae, Convolvulaceae, Solanaceae. 32 plates. G. Bell & Sons, London. 1965. 10/6d.

*Illustrated Dictionary of Botanical Terms* (excerpt from). By JOHN LINDLEY. With an introduction by ALICE EASTWOOD and a foreword by JOSEPH J. GRAHAM. 48 pp. School of Earth Sciences, Stanford University. 1964.



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# MADROÑO

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# A TAXONOMIC REVISION OF SECTION SONORICOLA OF THE GENUS VERBESINA L. (COMPOSITAE)

JAMES R. COLEMAN

*Verbesina* is the largest genus in the subtribe *Verbesineae* of the tribe *Heliantheae*, the number of species being about 250. The genus is entirely new world with the species occurring from the United States to Argentina but being best developed in the tropics.

This paper is part of a Ph. D. thesis submitted to Indiana University. The work was supported by fellowships from the National Science Foundation and Indiana University. I wish to express gratitude to Charles B. Heiser for suggesting this investigation and to Annetta Carter for generously supplying valuable materials and information. My current address is: Institute de Botânica, São Paulo, Brazil.

The genus was last treated in its entirety by Robinson and Greenman (1899) in which treatment they recognized 109 species in 12 sections. During this century one section, *Lipactinia*, was revised by Blake (1925) and recently three others, *Pterophyton*, *Sonoricola* and *Ximenesia*, were revised by Coleman (1964). This paper is based on the revision of one of these sections, *Sonoricola*.

Section *Sonoricola* is a natural group of Baja California and northern mainland Mexico, being best developed in Baja California where seven of its nine species occur. Endemism appears to be the rule in this section with only one species, *V. chihuahuensis* Gray, occupying any considerable range. Additional collecting in Baja California may show that this endemism more apparent than real. The species occur in regions of coastal sand dunes, semi-desert plateaus and, more commonly, mountains. This includes altitudes of from near sea level to approximately 10000 feet.

Robinson and Greenman (1899) treated section *Sonoricola* as composed of six species. It is here expanded to nine species.

Section *Sonoricola* is most closely related to sections *Pterophyton* and *Ximenesia* and is separable from them as shown in the following key:

- Erect perennials; stems winged or wingless; petiole bases mostly exauriculate; rays yellow, rarely lacking; chaff not particularly slender; awns, if present, not filiform.
- Herbaceous; stems winged or wingless; ray achenes, if present, not tuberculate; awns lacking or quite short, rarely to 3 mm long. .... Sec. *Pterophyton*
- Fruticose or suffruticose; stems wingless; ray achenes, if present, tuberculate; awns mostly 3-7 mm long, rarely less. .... Sec. *Sonoricola*
- Annuals or prostrate perennials; stems wingless; petiole bases mostly conspicuously auriculate; rays orange or yellow; chaff quite slender, even filiform; awns filiform, occasionally lacking. .... Sec. *Ximenesia*

Unfortunately the amount of material available for crossing and cytological studies was quite limited. However chromosome counts were obtained for two species, *V. peninsularis* Blake and *V. oligocephala* Johnston (table 1). The counts were made by the aceto-carmin squash method on buds which had previously been fixed in a solution of 95% ethyl alcohol, chloroform and propionic acid (6:2:2). Meiosis of *V. peninsularis* was normal with 17 pairs being observed. Of the two plants of *V. oligocephala* examined, however, one showed 17 pairs plus one B chromosome whereas the second showed 17 pairs plus two B chromosomes. This is the first report of B chromosomes in *Verbesina*. These two species agree with the majority of the species of *Verbesina* counted thus far in having a haploid number of 17. However, counts of  $n = 16$  and 18 have been reported (De Jong and Longpre, 1963; Turner, Ellison, and King, 1961; Turner, Beaman, and Rock, 1961) and tetraploid species are known (Heiser and Smith, 1955; Coleman, 1964). The counts presented in this paper are the first reports for section *Sonoricola*.

The section has no economic importance.

TABLE 1. CHROMOSOME NUMBERS

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<i>V. peninsularis</i> Blake. $n = 17$ . Mexico, Baja California, near Rancho San Matias. A. Carter 4619 (IND, UC). Counted by J. R. Coleman.
<i>V. oligocephala</i> Johnston. $n = 17 + 1b$ and $17 + 2b$ . Mexico, Baja California, near Puerto Escondido. J. R. Coleman V6233 (IND). Progeny of A. Carter 4356 (UC).

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Section SONORICOLA Robinson and Greenman, Proc. Am. Acad. 16:542. 1899. Type species, *Verbesina dissita* Gray.

Fruticose or suffruticose; stems wingless; leaves all opposite or the uppermost alternate, petiolate (except *V. dissita*), the petioles narrowly to broadly winged and slightly decurrent or, more commonly, not so, quite lustrous to not at all so, mostly deltoid-ovate to lanceolate, sparingly to quite pubescent; phyllaries ca. 3-4—seriate, most narrowly to broadly oblong, at times spatulate; heads medium to large (ca. 1.7-4.5 cm wide); rays yellow, neutral or styliferous, sterile or fertile; disc florets yellow; ray achenes triangular in cross section, mostly awnless; disc achenes provided with well-developed lateral wings and 2 long (ca. 3.0-7.0 mm) awns.

#### KEY TO THE SPECIES

- Leaves sessile; disc achenes ca. 7-9 mm long and essentially glabrous.....1. *V. dissita*  
 Leaves petiolate; disc achenes less than 7 mm long or densely hirsute.  
   Leaves quite lustrous; petioles often broadly winged, some usually slightly decurrent.  
     Older stems waxy white, younger stems mostly white tomentose; inflorescences clustered amongst terminal foliage.....2. *V. oligocephala*  
     Stems not white; inflorescences borne well above terminal foliage.  
       Leaves quite scabrous; ray florets neutral.....3. *V. palmeri*  
       Leaves hispid; ray florets styliferous.....4. *V. hastata*



Leaves not particularly lustrous; petioles mostly narrowly winged and never decurrent.

Outer phyllaries lax; species of northern mainland Mexico.

Principal leaves often over 10 cm long; ray florets sterile; achenes oblong.

5. *V. leptochaeta*

Principal leaves rarely over 10 cm long; ray florets fertile; achenes cuneate.

6. *V. chihuahuensis*

Outer phyllaries erect; species of Baja California.

Leaves not densely pubescent, mostly quite membranaceous. 7. *V. peninsularis*

Leaves densely hispid-scabrous.

Leaves coarsely serrate; ray flowers awnless.....8. *V. erosa*

Leaves finely serrate; ray flowers awned.....9. *V. pustulata*

1. *VERBESINA DISSITA* Gray, Proc. Am. Acad. 20:299. 1885. Type, near All Saints Bay, Lower California, *Orcutt s. n.*, Sept. 1884, GH.

Suffrutescent, ca. 1 m tall; stems sparingly hispidulous near the inflorescences, otherwise glabrous; leaves mostly opposite, becoming alternate above, sessile, occasionally clasping the stem, mostly ovate, serrate to entire, acute or obtuse, to ca. 11 cm long, mostly 2–5 cm wide, hispid to smoothish, lustrous; inflorescences 3–16-headed, cymose-paniculate, pedicels ca. 2–10 cm long and stout, heads mostly 4.0–4.5 cm wide, the discs mostly 1.5–2.0 cm wide; phyllaries ca. 3-seriate, mostly broadly oblong, at times spatulate, the outer series 5–8 mm long, the inner series ca. 8–12 mm long, mostly acute, hirsute, black specked; ray florets ca. 10, neutral, ca. 2.0–2.5 cm long, the ligule oblong, the tube papillate, the ovary ca. 2.5–3.2 mm long, glabrous, awnless; disc florets mostly 13–14 mm long, the tube papillate or hirsute-papillate, the ovary ca. 5 mm long, sparingly hirtellous, the awns ca. 3.2–3.6 mm long, the style tips acute; receptacle conical; chaff mostly 10–13 mm tall, hirtellous, acute; disc achenes obovate, mostly 8–9 mm long, 5.5–7.0 mm wide, essentially glabrous, the wings to 3 mm wide, the margins often erose or wavy, the awns mostly 3.2–4.2 mm long, erect or bent inward so as to cross each other.

Distribution. Sand dunes, coastal regions of extreme southern California and northern Baja California.

Specimens examined: CALIFORNIA. Orange Co.: near Arch Beach, *Bradshaw s. n.*, May 1903 (UC). BAJA CALIFORNIA. La Grulla, *Orcutt 355* (UC); Sanzal, *Orcutt s. n.*, May 21, 1886 (F, NY, UC); near Descanso Point, *Wiggins 11904B* (TEX, UC); Todos Santos., *Brandege s. n.*, May 10, 1897 (UC); Todos Santos Bay, *Orcutt 1233* (UC).

*Verbesina dissita* appears somewhat intermediate between sections *Sonoricola* and *Pterophyton*. It possesses the long pappus awns characteristic of section *Sonoricola* and is geographically associated with that section. However the sessile leaves, large heads and the achenes (except the awns) are somewhat suggestive of *V. lindheimeri* Rob. & Greenman of section *Pterophyton*.

In this treatment *V. dissita* is considered closest to *V. oligocephala*, *V. palmeri* and *V. hastata*, but is rather distinct from each by virtue of its

sessile leaves and glabrous achenes. It shares lustrous foliage with each, neutral ray florets with the first two species and subglabrous or merely hispid foliage with the latter.

2. *VERBESINA OLIGOCEPHALA* Johnston, Proc. Calif. Acad. 12:1200. 1924. Type, on a rocky slope in the mountains back of Aqua Verde Bay, Lower California, *Johnston 3899*, UC.

Spreading shrub ca. 1.5–2.0 m tall; older stems waxy white with bases of old hairs, younger stems often white tomentose; leaves opposite or the uppermost alternate, petioles ca. 1.5–3.0 cm long, cuneately winged, often auriculate, clasping the stem and decurrent for ca. 4–6 cm, mostly ovate but to lance-ovate or lanceolate, coarsely crenate-dentate to subentire, acute or obtuse, rarely subacuminate, mostly 6–14 cm long, 2.0–7.5 cm wide, scabrous, lustrous; inflorescences corymbose, mostly 2–8 headed, scarcely or not at all extending beyond the upper foliage, heads ca. 2–3 cm wide, discs ca. 1.8–2.2 cm wide; phyllaries ca. 3-seriate, ovate to oblong, the distal half often greatly expanded, subequal, mostly 6–8 mm long, mostly obtuse, the margins ciliate; ray florets 8–12, neutral, ca. 1.3–2.0 cm long, the ligule oblong or elliptic-oblong with the tube and base hirsute, the ovary ca. 2.0–2.5 mm long, papillate, awnless; disc florets ca. 10–12 mm long, the lower half of the corolla hirsute, the ovary ca. 3.5–4.5 mm long, densely upwardly hirsute, the awns ca. 5–7 mm long, the style tips acute; receptacle low convex; chaff mostly 9–12 mm tall, acute, the margins ciliate, subscarious; disc achenes cuneate, ca. 7 mm long, 4–5 mm wide, densely upwardly hirsute, the wings to ca. 1.5 mm wide, the margins ciliate, the awns ca. 5–7 mm long, slightly unequal, mostly spreading.

Distribution. Northern sector of the Sierra de La Giganta, Baja California.

Specimens examined. BAJA CALIFORNIA. Near Puerto Escondido, *Carter 4356* (UC); *Carter & Kellogg 2855* (UC); *Carter 4345* (UC); near Loreto, *Carter & Kellogg 2834* (UC) *Carter 3705* (UC); Arroyo Gabilan, *Carter & Ferris 4079* (UC); near San Javier, *Carter & Ferris 3807* (UC).

*Verbesina oligocephala* has its closest affinities with *V. palmeri*, differing most strikingly from that species by its whitish stems and short inflorescence.

3. *VERBESINA PALMERI* Wats., Proc. Am. Acad. 24:56. 1889. Type, in canons above Los Angeles Bay, *Palmer 528*, UC!, isotype, NY!

Suffrutescent, ca. 1.0–1.3 m tall; stems hispid-scabrous; leaves mostly opposite, alternate above, petioles to ca. 2 cm long, winged (wings 3–16 mm wide), often subauriculate, clasping the stem and decurrent for up to ca. 1 cm, deltoid, ovate or lance-ovate, repandly serrate-dentate to entire, acute or acuminate, to ca. 8.5 cm long, mostly ca. 5 cm long, to ca. 6.5 cm wide, commonly 2.5–4.0 cm wide, lustrous, scabrous; inflorescences corymbose, ca. 5–7-headed, pedicels mostly 2–5 cm long, heads ca. 2.5 cm wide, discs ca 8–10 mm wide; phyllaries ca. 3–4-seriate, the

outer series obovate to oblong, 2.5–5.0 mm long, obtuse, the inner series oblong to lance oblong, 6–8 mm long, acute; ray florets ca. 10, styliferous, sterile, ca. 1.0–1.5 cm long, the ligule oblong to elliptic-oblong, the tube hirtellous, the ovary ca. 1.8–2.3 mm long, awnless; disc florets mostly 9–12 mm long, the tube hirtellous, the ovary 3–5 mm long, densely upwardly hirsute, the awns ca. 4–5 mm long, the style tips acute; receptacle low convex; chaff mostly 9–10 mm tall, the margins ciliate, the tips acute or acuminate, some recurved; disc achenes obovate, ca. 6–7 mm long, 4–5 mm wide, upwardly hirsute, the wings to ca. 1.3 mm wide, the margins ciliate, the awns ca. 4–5 mm long, spreading to varying degrees.

Distribution. Northeastern Baja California.

Specimens examined. BAJA CALIFORNIA. Canyon del Diablo, E bank of Sierra San Pedro Martir, *Chambers 563* (UC).

*Verbesina palmeri* appears quite close to *V. hastata*, differing from that species by possessing scabrous leaves, chaff yellowish throughout and pappus awns ca. 4–5 mm long. *Verbesina hastata* has smooth or merely hispid leaves, chaff often black apically and pappus awns 6–7 mm long.

4. VERBESINA HASTATA (Kellogg) Curran, Bull. Calif. Acad. 1:140. 1885. *Liptochaeta hastata* Kellogg, Proc. Cal. Acad. 2:106, fig. 31. 1861. Type, illustrated cited! *V. venosa* Greene, Bull. Torrey Club 9:110. 1882. Type, Cedros I., *Veatch?*, UC. *Encelia cedrocensis* Rose, Contr. U. S. Natl. Herb. 1:17. 1890. Type, Cedros I., *Palmer 741*, UC!

Shrub to ca. 1 m tall; stems subglabrous; leaves all opposite or the upper alternate, petioles to ca. 1.5 cm long, winged (the wings to ca. 5 mm wide), often clasping the stem and decurrent for ca. 3–5 cm, mostly ovate but to lanceolate, repandly dentate to entire, acute or acuminate, rarely obtuse, mostly 5–7 cm long, 2–4 cm wide, subglabrous to hispid, lustrous; inflorescences loosely corymbose, to ca. 10-headed, the pedicels mostly under 5 cm long, the heads ca. 2.0–2.5 cm wide, the discs ca. 1.0–1.5 cm wide; phyllaries 3–5—seriate, the outer series obovate or spatulate, mostly 3–5 mm long, obtuse, the inner series lanceolate, ca. 6.7–7.5 mm long, acute; ray florets ca. 12, styliferous, sterile, ca. 1 cm long, the ligules broadly oblong, the tube hirsute, the ovary 1.5–2.2 mm long, awnless; disc florets mostly 9–12 mm long, the tube hirsute, the ovary ca. 3.0–4.2 mm long, densely upwardly hirsute, the awns to ca. 6.5 mm long, the style tips acute; receptacle low convex; chaff ca. 6.5–8.5 mm tall, sparingly hirtellous, the apical portion black, acute; disc achenes obovate, ca. 5–6 mm long, 2.8–4.2 mm wide, the margins ciliate, the awns to ca. 7 mm long, mostly slightly unequal, erect or somewhat spreading.

Distribution: Cedros I., Baja California.

Specimens examined. BAJA CALIFORNIA. Cedros I., *Rose 16117* (NY); *Anthony 63* (NY, UC); *Anthony 296* (F, UC).

See discussion under *V. palmeri* for relationship to that species.



5. *VERBESINA LEPTOCHAETA* Gray, Proc. Am. Acad. 21:389. 1886. Type, near Batopilas, Chihuahua, *Palmer 170*, GH!

Bushy shrub ca. 1.5–2.5 m tall; stems mostly glabrous, hispid near the heads; leaves opposite, petioles to ca. 4 cm long, very narrowly winged, ovate-deltoid to broadly elliptical, serrate, acute, to ca. 13 cm long, to ca. 8 cm wide, scabrous; heads subsolitary, discs ca. 2 cm wide; phyllaries 2–3-seriate, narrowly oblong, subequal, ca. 7 mm long, acute, the outer series lax herbaceous; ray florets styliiferous, sterile, the ligule linear, the ovary ca. 5 mm long, sparingly hirsute; chaff ca. 10 mm long, subacute; disc achenes oblong, ca. 6–7 mm long, 2.5–3.0 wide, hirsute, the wings ca. 0.5–1.0 mm wide, the margins ciliate, the awns subequal, ca. 4–5 mm long, suberect.

*Verbesina leptochaeta* is known only from its type specimen which is unfortunately in rather poor condition. The species fits well into section *Sonoricola*, but its relationships are obscure. Blake (1924) considers it to have an affinity with *V. peninsularis*, but certainly this relationship would not be a very close one. It resembles the only other mainland species of the section, *V. chihuahuensis*, in having lax, spreading outer phyllaries.

6. *VERBESINA CHIHUAHUENSIS* Gray, Proc. Am. Acad. 21:389. 1886. Type, Santa Eulalia Mountains, near Chihuahua, on limestone, in canons, *Pringle 657*, GH, isotypes, F!, NY! *V. parrasana* Brandege, Univ. Calif. Publ. Bot. 4:191. 1911. Type, Sierra de Parras, *Purpus 4635*, UC!

Suffrutescent, to ca. 0.75 m tall; stems puberulent to densely pilose, occasionally reddish; leaves opposite below, alternate above, the petioles to ca.  $\frac{1}{4}$  the length of the leaf, narrowly winged, ovate-deltoid to lanceolate, coarsely serrate or dentate to subentire, acute, rarely obtuse, to ca. 11 cm long, commonly 4–6 cm long, mostly 1.5–3.0 cm wide, hispid, at times densely pilose; inflorescences mostly 1–4-headed, the pedicels quite slender, mostly 5–6 cm long, the heads ca. 2.5–3.5 cm wide, the discs ca. 1.0–1.5 cm wide; phyllaries ca. 3-seriate, linear-oblong to lanceolate, subequal, to ca. 15 mm long, mostly 5–10 mm long, mostly acute, the outer series lax; ray florets ca. 12–14, commonly styliiferous and fertile, rarely neutral, mostly 1.8–2.4 cm long, the ligule linear to oblong, the tube hirsute, the ovary 2.5–3.5 mm long, subglabrous, awnless; disc florets mostly 7.5–10.0 mm long, the corolla hirsute throughout, the ovary ca. 3.0–4.5 mm long, densely upwardly hirsute, the awns slender, to ca. 4–5 mm long, the style tips attenuate; receptacle conical; chaff 5.5–8.5 mm tall, sparingly hirtellous, subscarios, often black-specked, acute-attenuate; ray achenes ca. 3–4 mm long, awns usually lacking, occasionally to ca. 2.5 mm long; disc achenes cuneate, mostly 4–7 mm long, 2.5–3.5 mm wide, densely upwardly hirsute, the wings to ca. 1 mm wide, the awns equal, to ca. 4–5 mm long, erect.

Distribution. Northern regions of the Mexican Plateau.



Specimens examined. CHIHUAHUA. Santa Eulalia Plains, *Wilkinson s. n.*, 1885 (F); mountains NW of Chihuahua, *Le Sueur 1020* (F, TEX); near Piramide, *Johnston & Muller 1421* (GH); near Chihuahua, *Pringle 1058* (NY, UC). COAHUILA. Near Saltillo, *Palmer 407* (F, NY); Carneros Pass, *Pringle 2782* (F); Sierra de la Paila, *Purpus 4694* (UC); near Parras on Sierra Negras, *Stanford, Retherford, & Northcraft 288* (NY). DURANGO. Durango, *Palmer 322*, (F, NY). ZACATECAS. Near Concepcion del Oro, *Stanford, Retherford, & Northcraft 515* (UC).

*Verbesina chihuahuensis* shows a strong similarity to *V. encelioides* (Cav.) Benth. & Hook. of section *Ximenesia*. This similarity includes the ray florets which in both cases are styliferous and fertile, the achenes, both ray and disc, and the spreading outer phyllaries. The species contrast most notably in regards to habit, *V. chihuahuensis* being perennial and *V. encelioides* being annual.

7. VERBESINA PENINSULARIES Blake, Proc. Biol. Soc. Wash. 37:58. 1924. Type, 32 km E of San Ignacio, Baja California, *Wilson & Goldman 7227*, US. *V. cayucensis* Jones, Contr. West. Bot. 18:76. 1933. Type, Cayuca Ranch, Loreto, Baja California, *Jones 27718*, UC!

Suffruticose or fruticose, ca. 0.5–1.5 m tall; stems hispidulous-puberulent, occasionally reddish; leaves mostly opposite, alternate above, the petioles ca. 2 cm long, narrowly cuneately winged, ovate-deltoid to lanceolate, rather coarsely serrate, often doubly serrate, acute or acuminate, to ca. 13.5 cm long, mostly 2.5–5.0 cm wide, scabrous or subscabrous, membranaceous; inflorescences subsolitary or cymose, to ca. 6-headed, the heads mostly 1.7–2.5 cm wide, the discs ca. 10–12 mm wide; phyllaries subequal, mostly 5.5–7.5 mm long, acute or obtuse, the margins ciliate; ray florets ca. 10, styliferous, fertile, mostly 1.0–1.5 cm long, the ligule linear-oblong, the tube hirsute, the ovary ca. 2 mm long, glabrous, awnless; disc florets ca. 7–8 mm long, the tube hirsute, the ovary ca. 2–3 mm long, the style tips attenuate; receptacle low convex; chaff ca. 7–8 mm tall, subglabrous, obtuse or acute, scarious; ray achenes ca. 4 mm long, awnless; disc achenes obovate, ca. 6–7 mm long, ca. 4 mm wide, sparingly hirsute, the wings to ca. 3 mm wide, the margins erose and sparingly ciliate, the awns subequal, mostly 2.5–3.0 mm long, erect.

Distribution. Northern region of the Sierra de La Giganta, Baja Calif.

Specimens examined. BAJA CALIFORNIA. Near Canipole, *Wiggins 11455* (UC); Cerro de La Giganta, *Carter & Kellogg 3120* (UC); *Carter & Ferris 3989* (UC); near San Javier, *Carter & Ferris 3851* (UC); *Chisaki & Carter 130* (UC); Rancho San Matias, *Carter 4619* (UC); La Esperanza, *Carter 4373* (UC); near Llanos de San Juan, *Carter 4499* (IND, UC).

*Verbesina peninsularis* differs from *V. erosa* to which it is mostly closely related by having membranaceous leaves which are not densely pubescent.

The rather meager distributional data available for this section indicates that sympatry is not common. A definite exception is however presented by *V. peninsularis* and *V. oligocephala*; however, the specimens examined give no reason to suspect that hybridization is occurring.

8. *VERBESINA EROSA* Brandegee, Proc. Calif. Acad. 3:146. 1891. Type, Sierra de San Francisquito, *Brandegee 316*, UC!

Suffruticose, ca. 1–2 m tall; stems hirsute-hispid, often reddish; leaves mostly opposite, the uppermost alternate, the petioles mostly 1–2 cm long, cuneately winged, mostly ovate to lance-ovate, coarsely serrate or doubly serrate to subentire, acute or acuminate, to ca. 15 cm long, mostly 3–6 cm wide, densely hispid-scabrous; inflorescences subcorymbose, 3–14-headed, pedicels mostly 1–5 cm long, the heads mostly 2–3 cm wide, the discs ca. 8–10 mm wide; phyllaries 2–3-seriate, oblong or lanceolate, subequal, mostly 5–9 mm long, acute or subacute, margins of the inner series ciliate; ray florets ca. 8–10, styliferous, fertile, ca. 0.8–1.3 mm long, the ligule oblong or elliptic-oblong, the tube and base densely hirsute, the ovary ca. 1.5–2.2 mm long, papillate, awnless; disc florets mostly 5–8 mm long, the tube densely hirsute, the ovary ca. 2.0–2.5 mm long, hirsute, the awns 2–3 mm long, the style tips acute; receptacle conical; chaff ca. 4.5–7.8 mm tall, hirsute-hirtellous, acute, the margins ciliate; ray achenes 2.2–4.2 mm long, awnless; disc achenes obovate, 4–6 mm long, 4.0–5.5 mm wide, subglabrous, often reddish, wings to ca. 1.8 mm wide, the margins entire or, more often, lacerate, the awns subequal, 2.8–4.0 mm long, slightly spreading.

Distribution. Mountains of the Cape region of Baja California.

Specimens examined. BAJA CALIFORNIA. Pescadero, *Brandegee s. n.*, Sept. 20, 1893 (UC); La Chuparosa, *Brandegee s. n.*, Oct. 2, 1899 (UC); Sierra de San Francisquito, *Brandegee s. n.*, Sept. 29, 1899 (F); Sierra San Laguna, *Brandegee s. n.*, Sept. 10, 1899 (NY); W side of Cape Region, *Brandegee s. n.*, Nov. 1902 (UC); San Filipe, *Purpus s. n.*, Jan.–Mar. 1901 (UC); Sierra El Taste, *Carter & Chisaki 3509* (UC).

*Verbesina erosa* has its closest affinity with *V. pustulata*, differing from that species by its more closely serrate leaf margins and awnless ray ovaries. These two species are so similar that it is quite possible that further collecting will show them to be conspecific.

9. *VERBESINA PUSTULATA* Jones, Contr. West. Bot. 18:77. 1933. Type, The Laguna, Laguna Mountains, Baja California, *Jones 22711*, UC!

Suffruticose, ca. 1–2 m tall; stems hispid, red; leaves opposite, the petioles ca. 1 cm long, narrowly winged, lance-ovate, closely serrate, acute or acuminate, to ca. 7 cm long, 2.5–3.0 cm wide, densely hispid-scabrous; inflorescences subcorymbose, ca. 4-headed, pedicels ca. 3 cm long; discs ca. 1 cm wide; phyllaries ca. 4-seriate, oblong or lanceolate, subequal, 5–7 mm long, acute, the margins ciliate; ray florets styliferous, the tube densely hirsute, the ovary ca. 1.5 mm long, glabrous, the awns ca. 1.7 mm long; disc florets ca. 9 mm long, the tube and throat hirsute, the ovary ca. 2.8 mm long, glabrous, the awns ca. 3.0–4.8 mm long, the style tips attenuate; receptacle conical; chaff ca. 7–8 mm tall, acuminate, subscarios, the margins ciliate; disc achenes (immature) obovate, 4–5 mm long, subglabrous, the wings narrow, the margins ciliate, the awns 2.8–3.5 mm long, one ca.  $\frac{1}{2}$  the length of the other.

*Verbesina pustulata*, known only from its type material, is most closely related to *V. erosa*. The reader is referred to the discussion under that species.

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## ESCOBARIA LEEI BÖDEKER REDISCOVERED IN NEW MEXICO

EDWARD F. CASTETTER AND PRINCE PIERCE

This species was briefly described by Bödeker in 1933 as follows: "*Escobaria Leei* (Rose as *Mammillaria* 1924 No. 282) Böd. From New Mexico. Plants proliferating at the ground, only 15 mm. high and 5 mm. thick; spines numerous, white, up to 3 mm. long." Although Bödeker refers to a *Mammillaria* specimen No. 282 of J. N. Rose, we have been unable to locate any reference or description of this plant by Rose in the literature. Despite the obvious shortcomings of Bödeker's description, the name *E. leei* holds priority and we have decided to publish a detailed, meaningful description of the species on the basis of field and laboratory studies of numerous specimens.

In the U. S. National Herbarium is an herbarium sheet (US 72134) with the following information on the label: Rattlesnake Canyon, 30 miles southwest of Carlsbad, altitude 5500 ft., W. T. Lee, 1924. Attached to the herbarium sheet is a piece of notepaper which reads: "Found in Rattlesnake Canyon, 30 miles southwest of Carlsbad, New Mexico, at 5500 ft. elevation, growing on limestone ledges on north facing slopes. It is new. I have never seen it before. W. T. Lee."



FIG. 1. *Escobaria leei*

This sheet bears, in Rose's handwriting, the number 24,282 which was his greenhouse number and represents specimen 282 collected in the year 1924. Conrad Morton of the U.S. National Herbarium is of the opinion that, although there is no record of it, Bödeker may have visited the National Herbarium at some time while Rose was there and may very well have studied this specimen; he is convinced that this specimen is the basis for *Escobaria leei* (from a letter by S. G. Shetler to L. Benson, Feb. 9, 1965).

Also in the National Herbarium is a carton containing a whole plant consisting of a cluster of numerous small stems together with a slip of paper bearing the following annotation: "*Neom. Leei*", Carlsbad, N. Mex., 24,282, see *N. lasiacantha*, April 1925, Lee, 24,282. Thus, both the slip of paper and the carton plant tie in with the herbarium sheet by the same greenhouse number. The fact that Rose had marked this specimen as *Neomammillaria leei* indicates that he had considered describing it as a new species which, however, he never did.

Plants on the herbarium sheet (US 72134) and the carton specimen are designated as the lectotype of *E. leei*.

We recently found this species near the original collections site in Rattlesnake Canyon (fig. 1) about 30 miles southwest of Carlsbad, in the tributaries of this canyon and in Slaughter Canyon, at elevations of 4200 to 4800 feet, in the Guadalupe Mountains of southwestern New Mexico. We have studied the plants in situ and have grown them in our gardens (*Castetter & Pierce* 2397 through 2717, UNM).



ESCOBARIA LEEII Bödeker, Ein Mammillarien Vergleichs, Schlüssel 17, Neudam, Germany, 1933. Low growing plants usually forming densely spreading clumps bearing as many as 250 stems (usually not more than 100) formed by proliferation from the bases of stems of older plants and thus forming flat tufts or mats up to 15 cm in diameter; with most clumps, all stems remaining immature for a considerable period of time; mature stems as much as 7.5 cm long and 3 cm in diameter but usually not exceeding 3.5 by 1.7 cm; stems typically clavate, less frequently cylindric, the smallest ones subglobose and as little as 3 cm in diameter; aerial spiny portion of stem extending as much as 5 cm above ground level, densely white spiny, the lower part of the stem subterranean, bearing dry knobby tubercles although many spines on these tubercles remain intact; flesh of stem ranging from green to pale or deep dull magenta, firm, tough; root system mainly fibrous, but usually with a single moderately slender taproot which is connected to the original stem of the clump. Tubercles cylindric or nearly so, small, as much as 0.5 cm long by 2–3 mm wide, almost completely obscured by the dense spine clusters; some of the older tubercles grooved on the upper surface, the groove extending from the tip of the tubercle to  $\frac{1}{2}$  or more of its entire length, short white woolly, with a dense woolly tuft at the base; aeroles circular to broadly elliptic in outline, densely white woolly becoming dark in age. Central spines irregular in length, but as much as 1 cm long, stout, straight, white to yellowish-brown tipped, varying in number from 6–22, 6 or 7 of them stouter than the others, and 1 of these, not necessarily the longest of the group, occupying a truly central position, porrect; most of the central spines depressed and subcentral in appearance; radial spines 40–85, white, very slender, irregular in length, some of them curved or twisted at the tip, both radial and subcentral spines disposed in an eccentric whorl; all spines on very young plants densely short white pubescent, those on older stems naked. Flowers funnelform, 1.7–2.0 cm long, 1.2–1.8 cm in diameter, overall color dull medium brownish-pink; outer perianth segments terminating in a short awn, the broad midstripe brown to greenish-brown, ciliate on the margins, bearing copious long white translucent, curled, twisted, kinked hairs on the upper  $\frac{1}{2}$ – $\frac{3}{4}$  of the segment, some of them branched near the bases; inner perianth segments each ending in an abrupt short pointed tip, white, the broad midstripe rose to dull orchid with a brownish infusion; stigma lobes 4–6, short oblong, pure white. Fruit pale brownish-green to green with a pinkish cast, 1.2 cm long, about 0.5 cm in diameter, most of them bearing 1–several pubescent scales; perianth persistent; dry seeds nearly obovoid, more specifically asymmetrically pear-shaped on one side to somewhat kidney shaped on the other, alveolate, lustrous reddish-brown, about 1.25–1.5 mm long by 1 mm wide, hilum subbasal, flat.

Plants usually begin to bloom in their native habitat in mid-April to early May and continue to do so for several weeks, closing at night and opening about noon.

This species differs from all others of the genus in New Mexico in that the aerial portion of many of the medium-sized and smaller stems has a unique shape which may be described as blockish-spherical, a characteristic attributable to the fact that the central part of the aerole projects beyond the spine cluster, owing to most spines being depressed.

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## NEW RECORDS OF MYXOMYCETES FROM CALIFORNIA I.

DONALD T. KOWALSKI

A search of the pertinent literature, which consists of some eight papers dealing with slime molds of California, reveals that 154 species of Myxomycetes have been definitely recorded as occurring in California. Hagelstein (1944) listed additional species that have been reported, but he considered their authenticity questionable for various reasons. The largest collection was that of Plunkett (1934). He gave a list of 87 species, most of which were collected within a 50 mile radius of Los Angeles. The only papers dealing with Myxomycetes of Northern California were those of Cooke (1949) and Pratt and Pratt (1944). All of Cooke's collections were made on the slopes of Mt. Shasta and the Pratts collected their specimens within a 25 mile radius of San Francisco. Thus, essentially no Myxomycetes have been reported to date from the Sacramento Valley.

In the fall of 1964 I initiated a study of the Myxomycetes of California, and since have collected exclusively in Butte Co. Most of the collections listed below have come from Lower Bidwell Park, Chico. This is one of the few remaining areas in the Sacramento Valley that has not been disturbed for reasons of agriculture. Thus, it represents a particularly fruitful area and the species found here may have been abundant at one time throughout the Great Valley. In this first of a series of papers, 11 species of Myxomycetes are listed as new to the state in the sense that no report of their occurrence in California has been previously published. This brings the total number of slime molds found in California to 165 species.

All collections have been deposited in the Herbarium of the University of Michigan. The names of the organisms are those accepted by Martin (1949) and the numbers are my own.

## LICEACEAE

*Licea pusilla* Schrad. On badly decayed coniferous wood approximately 5 miles N of Forest Ranch, 3500 ft., 1220, Mar. 19, 1965. The sporangia are purplish-brown, sessile, and dehisc by preformed lobes, appearing stellate at maturity. This exceedingly tiny species, the maximum diameter of the sporangia being only 1.0 mm, has been found previously only as far west as Iowa, and is considered rare. This, however, is undoubtedly due to its inconspicuousness and it may occur throughout the United States.

## TRICHIACEAE

*Perichaena vermicularis* (Schw.) Rost. No. On a dead herbaceous stem in Lower Bidwell Park, 1079, Jan. 16, 1965. This collection consists of a few scattered plasmodiocarps, but can be clearly identified by its light brown color and large spores, reaching 14.0  $\mu$  in diameter.

*Arcyodes incarnata* (Alb. & Schw.) O. F. Cook. On a decorticated log near the Sacramento River approximately 1.7 miles S of Sacramento Road, 972, Dec. 12, 1964. The fructifications consist of sessile, heaped, pinkish sporangia, each about 1 mm in diameter. They are quite distinctive by reason of their persistent peridia. This is considered a rare species and is known from scattered collections across the United States. It is not new to the west coast, having been reported from Oregon.

*Arcyria occidentalis* (Macbr.) G. Lister. On decayed wood, 5 miles N of Forest Ranch, about 3500 ft., 1161, Mar. 6, 1965. This collection has spores averaging 9–10  $\mu$  in diameter. All published descriptions list the spores as 7–8  $\mu$  in diameter. In all other respects, however, it fits perfectly with the description given by Martin (1949). In my opinion, this discrepancy is not large enough to warrant the establishment of a new species or variety.

*Arcyria insignis* Kalchbr. & Cooke. Three collections, all on decayed wood in Lower Bidwell Park: 1049, Dec. 31, 1964; 1268, Apr. 17, 1965; and 1302, Apr. 24, 1965. This common species has previously somehow been overlooked in California. It can be distinguished from other members of the genus by its small size, firmly attached capillitium, and pinkish color.

## STEMONITACEAE

*Enerthenema papillatum* (Pers.) Rost. Two collections, both on decayed wood in Lower Bidwell Park: 1086, Jan. 16, 1965 and 1307, Apr. 24, 1965. This common species is characterized by having the columella expanding into a disk at the apex of the sporangium, and nonclustered spores which are only minutely warted.

*Stemonitis hyperopta* Meylan. On decayed wood in Lower Bidwell Park, 1111, Jan. 24, 1965. This collection consists of just a few sporangia, but it is easily recognizable by the reticulate spores, which are inconspicuously and irregularly banded-reticulate. It is another rare species which is known from scattered collections from Maine to Washington.



*Stemonitis pallida* Wing. Two collections, both on decayed wood in Lower Bidwell Park on Apr. 24, 1965: 1301 and 1310. This species is characterized by having spores that are nearly smooth and over  $7.0\ \mu$  in diameter, sporangia which are pallid in color, and a surface net which is poorly developed towards the apex. It is an uncommon species, previously being found only as far west as Iowa.

*Comatricha cornea* Lister & Cran. Three collections: 939 on bark of a fallen tree in Lower Bidwell Park, Nov. 26, 1964; 986 and 1002 which developed in moist-chamber culture on bark taken from living trees along the Sacramento River 1.7 miles S of Sacramento Road, Dec. 12, 1964. This species has been reported only from Michigan, Kansas, and Iowa and then only from moist-chamber culture. I have thus collected this species in the field for the first time (939). The small collar at the base of the columella and the translucent stalk are the outstanding characteristics of this minute species.

#### DIDYMIACEAE

*Didymium serpula* Fries. Two collections, both from Lower Bidwell Park on decaying leaves: 1009, Dec. 31, 1964 and 1183, Mar. 14, 1965. The grayish plasmodiocarps with vesiculose bodies attached to the capillitium separate this species from others in the genus. It is a very rare taxon, previously found only as far west as Iowa.

*Didymium minus* (Lister) Morgan. On a decaying leaf in Lower Bidwell Park, 1115, Jan. 24, 1965. This is a cosmopolitan species, somehow overlooked or misidentified in California until now. Its major characteristics are: stalked subglobose sporangia, the stalks being dark-brown or black, and spores  $8\text{--}11\ \mu$  in diameter. *Didymium melanospermum* (Pers.) Macbr. is closely allied with this species but has spores  $10\text{--}14\ \mu$  in diameter. It is almost a certainty that many California collections labeled *D. melanospermum* are in reality *D. minus*, since many authors consider *D. minus* a variety of *D. melanospermum*. This probably accounts for its exclusion from California in the published reports.

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# CONTRIBUTION TO THE EMBRYOLOGY OF *MUILLA*, WITH A REMARK ON THE TAXONOMIC POSITION OF THE GENUS

ROLF Y. BERG AND JACK R. MAZE

This paper is the first of an intended series on the tribe Allieae, subfamily Allioideae, of the family Liliaceae (*sensu* Krause, 1930) or Amaryllidaceae (*sensu* Hutchinson, 1959). This series will be a continuation of previous studies within the Liliaceae (Berg, 1958; 1959; 1960; 1962a; 1962b).

*Muilla* (anagram of *Allium*) is a small genus of five species native to the southwestern United States and Mexico (Ingram, 1953). Only one species, *M. maritima* (Torr.) Wats., was studied. Megasporogenesis, embryo sac development, and early endosperm development is described, as well as the accompanying changes in the ovule. The taxonomic significance of this new information is considered and inconsistencies with the present taxonomic position of *Muilla* are pointed out.

No information about the embryology of *Muilla* is available in the literature.

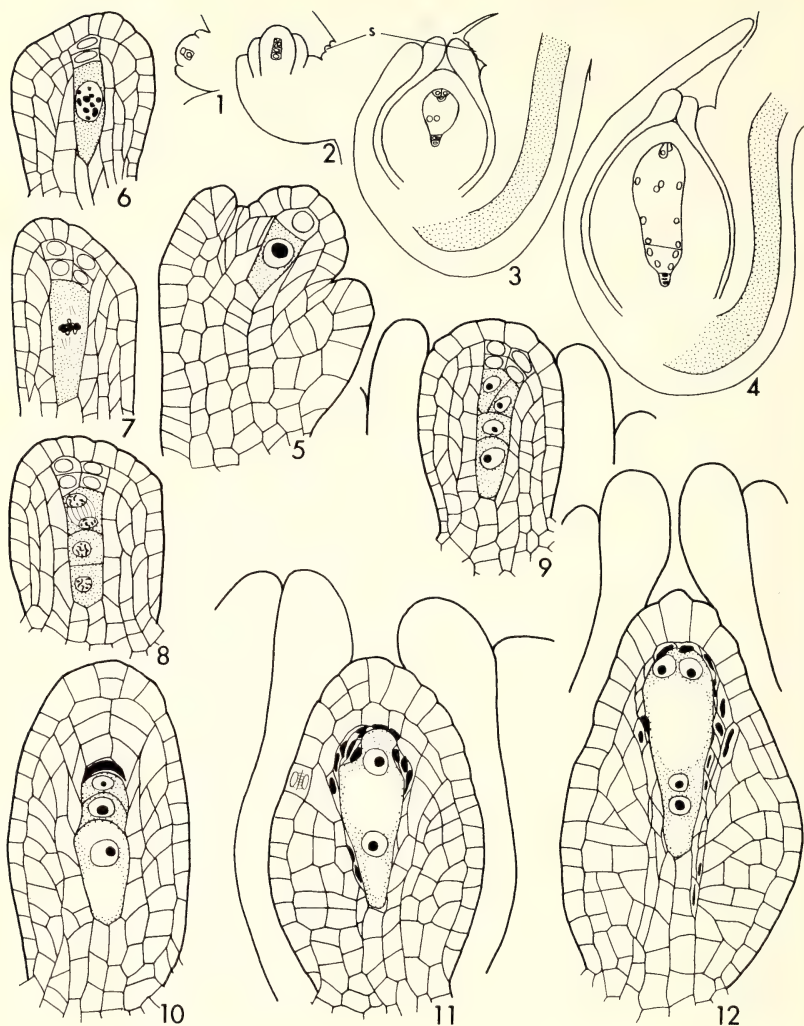
Material was collected from plants growing in an alkaline flat by the Pole Line Road, 1.1 miles north of Davis city limit, Yolo Co., California (DAV). Ovaries were fixed in Belling's modified Navashin fluid and dehydrated with tertiary butyl alcohol. Sections were cut at 10 and 12 microns and stained with safranin and fast green.

We are grateful to Marion S. Cave for critical review of the manuscript.

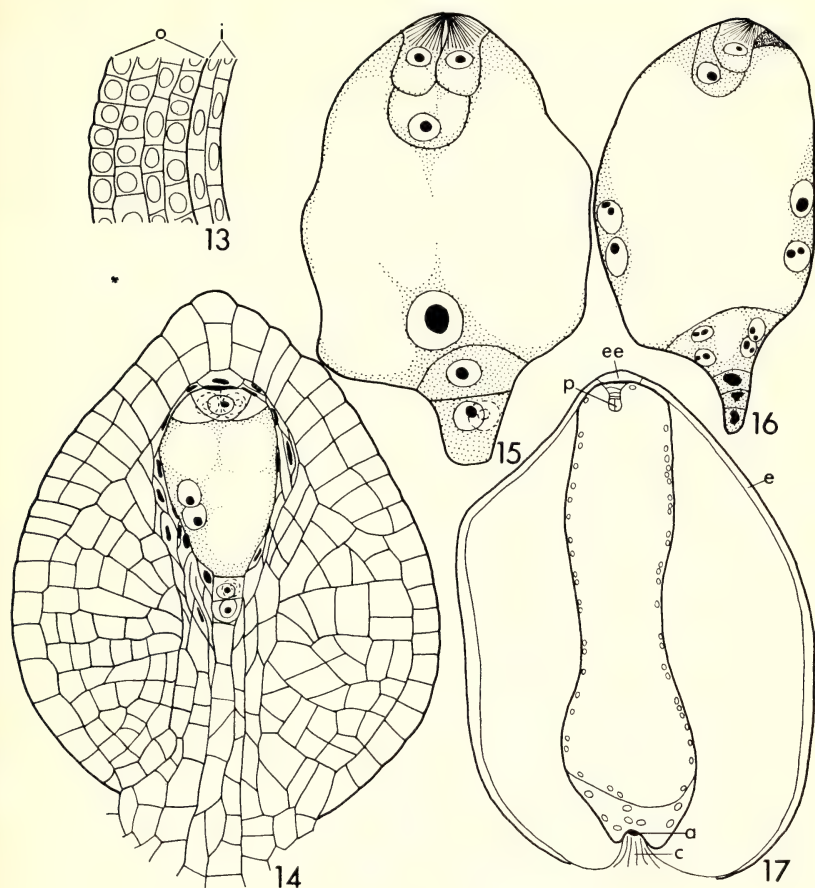
## OBSERVATIONS

**OVULE.** The ovule is anatropous, bitegmic, and crassinucellate (fig 3). At the early megaspore mother cell stage, it is short and nearly straight (fig. 1); at the megaspore tetrad stage it has become curved back approximately  $90^\circ$  (fig. 2); the anatropous stage is attained at ca. the four-nucleate embryo sac stage. There is no distinct funiculus. Raphides were not observed in the ovule, but may develop in the seed, since they are common in the ovary wall.

The inner integument develops near the apex at approximately the stage when the archesporial cell divides (fig. 1). Throughout development to the proembryo stage, the inner integument is two cells thick, except at the apex where it becomes three to five cells thick. The cells at the apex are more or less isodiametric whereas the remainder are elongate, being two to three times as long as broad at the time of fertilization (fig. 13). The outer integument begins to develop at the young megaspore mother cell stage and by the time of meiosis is well defined. It is three cells thick early in its development but soon develops into a structure that is four to five cells thick, the cells being approximately



FIGS. 1-12. 1, Ovule from a bud which was still underground, showing megaspore mother cell, primary parietal cell, and young annular inner integument; 2, Ovule from a bud located at the soil surface, showing a T-shaped tetrad and short integuments; 3, Ovule from a young bud, its pedicel still short, showing embryo sac before fusion of polar nuclei with inner integument closed above nucellus; 4, Young seed, showing helobial endosperm of four plus eight nuclei (all nuclei projected into one plane). Note characteristic elongation of outer integument; 5, young ovule, showing the arrangement of nucellar cells and an early stage of integument development; 6, Nucellus at a somewhat later stage with two parietal cells and megaspore mother cell in diakinesis; 7, Nucellus with two tiers of parietal cells and megaspore mother cell nucleus in metaphase I; 8, Linear tetrad in which division in upper dyad



FIGS. 13-17. 13, Integuments shortly before anthesis. *i*: inner integument, *o*: outer integument; 14, Nucellus from a medium-sized bud, showing numerous periclinal walls in upper part of nucellar epidermis, characteristic radial rows of cells in lower part, and a central core of narrow cells directly below the embryo sac; 15, Mature embryo sac as seen at anthesis; 16, Young helobial endosperm, both chambers four-nucleate. One synergid destroyed and antipodals degenerating; 17, Endosperm of 128 plus 8 nuclei surrounded by greatly enlarged nucellus. *a*: remnants of antipodal cells, *c*: central core of nucellar cells, *e*: one-layered nucellar epidermis, *ee*: two-layered nucellar epidermis, *p*: proembryo. Figs 13-15  $\times 360$ , fig. 16  $\times 90$ , fig. 17  $\times 56$ .

cell is slightly delayed; 9, T-shaped tetrad; 10, Nucellus showing first periclinal wall in epidermis, three tiers of parietal cells above the megaspores, and germination of lower megaspore; 11, Two-nucleate embryo sac stage; 12, Four-nucleate embryo sac stage. All parietal cells are absorbed. Note characteristic radial arrangement of cells in nucellus, *s*: stigmatoid tissue. Figs. 1-3  $\times 90$ , fig. 4  $\times 56$ , figs. 5-12  $\times 360$ .

isodiametric at the time of fertilization (fig. 13). The inner integument closes above the nucellus approximately when the embryo sac has reached the four-nucleate stage (figs. 11–12). The outer integument remains short for a long time so that the micropyle is formed by the inner integument only (fig. 3). However, after fertilization the outer integument grows considerably to form an unusual elongation towards the placenta (fig. 4).

The nucellus is medium-sized and completely surrounds the embryo sac at the time of fertilization (fig. 3). By this time the nucellus is approximately twice as long as the embryo sac and nearly as broad as long. The nucellar epidermis undergoes periclinal divisions, the first of which are found shortly after the germination of the functioning megaspore (fig. 10). These periclinal divisions in the nucellar epidermis continue until the time of fertilization but are restricted to the micropylar half of the nucellus only (figs. 11–12, 14), where a multiple epidermis of two, rarely three, layers eventually forms. Most of the body of the nucellus develops from the cells immediately beneath the epidermis. As the ovule grows, these subepidermal nucellar cells divide repeatedly, both periclinally and anticlinally, to form a characteristic pattern of radiating rows of cells (figs. 11–12, 14). After fertilization, more cells are added in this region and, as the ovule grows, most nucellar cells enlarge greatly. However, those of the central core region at the chalazal end of the embryo sac and those of the multiple epidermis at the micropylar end of the embryo sac remain small, and contribute only insignificantly towards the size of the post-fertilization nucellus (fig. 17).

**ARCHESPORIUM AND MEGASPOROGENESIS.** Only one archesporial cell is present in the ovule of *Muilla maritima*. Before the bud appears above ground in spring, the archesporial cell has divided to form the megaspore mother cell and a primary parietal cell (fig. 5). The primary parietal cell divides anticlinally, or periclinally, while the ovule is still in the megaspore mother cell stage (fig. 6). The two cells resulting from this division divide further to give rise to several parietal cells arranged in three, sometimes four, tiers above the megaspores (figs. 7–10). Some of the parietal cells remain until the two-nucleate stage in embryo sac development (fig. 11), after which all are absorbed by the developing embryo sac (fig. 12).

Megasporogenesis begins with the elongation of the megaspore mother cell (figs. 5–6). The spindle of the first meiotic division is longitudinally oriented and located a little above the middle of the cell (fig. 7). Nuclear division is followed by wall formation resulting in a dyad, the micropylar cell of which is slightly smaller than the chalazal one. Each dyad cell divides, the chalazal one normally by a cross-wall, the micropylar one by a wall which is sometimes horizontal but more often longitudinal or oblique (figs. 8–9). The division in the upper dyad cell may be slightly delayed (fig. 8). The tetrad of megaspores will be linear or T-shaped. At the time of formation, the two lowermost megaspores are



about equal in size and a little larger than the uppermost two (fig. 8). Embryo sac development is monosporic. The upper three megaspores degenerate, normally starting with the micropylar one (fig. 10) and proceeding progressively downward. In all ovules observed, with one possible exception, the chalazal megaspore functioned.

**MEGAGAMETOGENESIS AND MEGAGAMETOPHYTE.** By enlargement and vacuolization, the functioning megaspore becomes the embryo sac mother cell (fig. 10). Normally two vacuoles are formed, one above and one below the nucleus. As the embryo sac grows, the upper vacuole enlarges to become the central vacuole (figs. 11–12) while the lower one remains small and finally disappears (figs. 11–12, 14–15). The eight-nucleate stage is reached by three successive divisions of the embryo sac mother cell nucleus (figs. 10–12, 14). The micropylar part of the embryo sac increases more in size than the chalazal part (figs. 11–12), the latter eventually forming a small, narrow portion where the antipodals lie (figs. 14–15).

The mature embryo sac (fig. 15) is approximately one-and-a-half times as long as broad and of typically ovoid shape. The synergids are similar in size and appearance and are smaller than the egg. They are pear-shaped, each with a vacuole in the chalazal end, a nucleus located immediately above the vacuole, and a filiform apparatus radiating out from the point of attachment. The large egg cell has the nucleus in its lower end and is highly vacuolized. The three antipodal cells are arranged differently in different embryo sacs; most often two are found at the same level with the third one above (fig. 15) or below (fig. 14). Occasionally they are all in a row (fig. 16). The antipodal cells are as large as, or somewhat larger than, the synergids. They begin to degenerate a little before or during fertilization, but they are still obvious in early endosperm stages (figs. 16–17). The polar nuclei fuse before fertilization to form a large secondary nucleus, which lies close to the antipodals (figs. 14–15).

**FERTILIZATION AND ENDOSPERM DEVELOPMENT.** After pollination the pollen tube grows down the open stylar canal, which is lined with papillate stigmatoid tissue. The stigmatoid tissue of the style connects with a similar tissue on the placenta, some of which is apparent in figs. 2 and 3. One of the synergids is destroyed when the pollen tube enters the embryo sac. The other remains until more than a hundred nuclei have formed in the endosperm. Double fertilization occurs. Fusion between the secondary nucleus and one of the male nuclei takes place before the fusion in the egg nucleus. Apomictic phenomena were not observed.

The primary endosperm nucleus starts to divide before the zygote. Endosperm is helobial. The first nuclear division takes place in the chalazal end of the endosperm cell. It is followed by the formation of a transverse wall, which cuts off a smaller chalazal chamber from the larger micropylar one. In both chambers free nuclear divisions occur, and in the beginning they are synchronous. The following stages were

observed (nuclei of micropylar chamber/nuclei of chalazal chamber): 1/1, 2/2, 4/4, 8/4, 16/4, 32/4, 8/8, 16/8, 128/8. To judge from this series, nuclear divisions occur simultaneously in the two chambers until four nuclei are present in each (fig. 16). Then development slows down in the chalazal chamber: after eight, or possibly sometimes only four, nuclei have been formed in this chamber, nuclear divisions apparently cease. The nuclei already present become hypertrophied to some extent and the chamber shows signs of degeneration. Since later stages were not present in our material, the ultimate fate of the chalazal endosperm chamber could not be ascertained. In the micropylar chamber, nuclear divisions continue (figs. 4, 17), and the endosperm proper is wholly or largely developed from this chamber.

#### DISCUSSION

A full discussion of embryologic similarities and dissimilarities between the genera of the tribe Allieae must wait until data, comparable to those presented above for *Muilla*, are available for the remaining genera of the tribe. Such a discussion will constitute the final paper of this series. However, in a preliminary way, a few interesting facts can be pointed out.

The tribe Allieae, as conceived by Krause (1930), consists of 16 genera, some of which later have been united. Embryologic information has, so far, been produced only for *Gagea*, *Allium*, *Nothoscordum*, *Brodiaea*, and *Leucocoryne*. *Gagea*, furthermore, is now generally considered to be a member of the subfamily Lilioideae (Berg, 1962b). The information on *Brodiaea* (which is at present under investigation by the senior author) is limited to a record of helobial endosperm in *B. peduncularis* (Stenar, 1949). We are left, therefore, with only three genera for our preliminary survey, viz. *Allium*, *Nothoscordum*, and *Leucocoryne* (table 1).

Of special interest is the lack of a parietal cell in all these three genera, as opposed to the presence of a multicellular parietal tissue in *Muilla*. Stenar (1932, p. 39) points to the absence of a parietal cell as a typical feature of the Allieae. The bisporic type of embryo sac development in *Allium* and *Leucocoryne* and the nuclear type of endosperm in *Allium* constitute additional important deviations from the *Muilla* pattern. *Allium* differs from *Muilla* also in the shape of the embryo sac, in the number of cell layers in the integuments, in the position of the secondary nucleus, and in other minor features. *Nothoscordum* is most similar to *Muilla*, but this genus is also set somewhat apart from *Muilla* by the nature of its nucellus and the nature of its synergids, as well as by the absence of a parietal cell, and the occurrence of an *Allium* type embryo sac in one of its species.

The "key combination" (Berg, 1962b) of "+ N He" (parietal cell present, normal- or *Polygonum* type embryo sac, and helobial endosperm) that characterizes *Muilla* is not found in any other genus of the

TABLE 1. EMBRYOLOGICAL COMPARISON OF SOME GENERA OF THE TRIBE ALLIEAE

	( + = yes or present, 0 = no or absent)			
	<i>Allium</i>	<i>Nothoscordum</i>	<i>Leucocoryne</i>	<i>Mulla</i>
No. of cell layers in inner integument	3-4		2	2
No. of cell layers in outer integument	4-10		2-4	3-5
Periclinal walls in nucellar epidermis	+	+	+ <sup>6</sup>	+
Numerous such walls	0	0	0 <sup>6</sup>	+
Bulk of nucellus produced from nucellar epidermis	0	0	0 <sup>6</sup>	0
Nucellar apex penetrated by embryo sac	0 <sup>1</sup>	0	0 <sup>6</sup>	0
Parietal cell	0	0	0	+
Type of embryo sac development	<i>Allium</i> <sup>2</sup>	<i>Polygonum</i> <sup>3</sup>	<i>Allium</i>	<i>Polygonum</i>
Lower spore functions	+	+	+	+
Length/width of embryo sac	4/2	3/2	3/2	3/2
Synergid filiform apparatus	0&+	+		+
Synergids vacuolated	0&+	0		+
Polar nuclei fuse prior to fertilization	0&+	+ <sup>5</sup>	+	+
Endosperm type	Nu	He <sup>4</sup>		He
References	Håkansson, 1951   Eckles, 1941   Cave, 1939 Jones and Håkansson, 1953 Emsweller, 1936   Messeri, 1931 Messeri, 1931   Schnarf, 1931 Murphy, 1946   Stenar, 1932 Rao, 1940 Schnarf, 1931 Schürhoff, 1922 Weber, 1929			

<sup>1</sup>Weber (1929), Håkansson (1951), and Hasitschka-Jenschke (1958) state that the nucellus is partly destroyed when the embryo sac is at the four-nucleate stage.

<sup>2</sup>Weber (1929) reported both mono- and tetrasporic embryo sac development for *Allium carinatum* and monosporic embryo sac development for *A. paradoxum*. However, the significance of these variants is questionable because both of these species reproduce by bulbets and either the embryo sac does not develop or, if it does, the embryo does not survive. All normally reproducing, amphimictic species show *Allium* type embryo sac development.

<sup>3</sup>One of the three species of *Nothoscordum* included in this table, *N. fragrans*, is different from the others in that the embryo sac development is of the *Allium* type (Messeri, 1931; Stenar, 1932). However, it is of interest to note that this species shows adventive polyembryony and may present a similar case as *Allium carinatum* and *A. paradoxum*, i.e. an abnormal deviation within its genus.

<sup>4</sup>Schnarf (1931, p. 242) states that nuclear endosperm has been encountered in *Gagea*, *Allium*, and *Nothoscordum*, a statement that as far as *Nothoscordum* is concerned is contrary to Stenar's (1932) observations.

<sup>5</sup>Polar nuclei fuse after fertilization, according to Håkansson (1953).

<sup>6</sup>Marion Cave, personal communication.



tribe Allieae. On the other hand, *Muilla's* key combination occurs in several genera of four other subfamilies of the Liliaceae *sensu* Krause, namely the Melanthioideae (Schnarf, 1929), the Asphodeloideae (Schnarf and Wunderlich, 1939; Cave, 1953), the Scilloideae (Wunderlich, 1937; Buchner, 1948), and the Aletroideae (Schnarf, 1929), as well as in some genera of the family Amaryllidaceae (Schnarf, 1931; Stenar, 1951), to which the Allioideae is referred by Hutchinson (1959).

From a taxonomic point of view, the difference in embryological characters that exists between *Muilla* and other genera of the Allieae, particularly *Allium*, is important since it indicates that *Muilla* certainly is more distantly related to *Allium* and the other Allieae here discussed than is now generally assumed. For lack of information about the embryological variation within the Allieae as a whole, this line of thought cannot possibly be pursued any further at this time. For the same reason a detailed elaboration on the embryologic similarity and possible relationship of *Muilla* to one or more genera of the Melanthioideae, Asphodeloideae, Scilloideae, Aletroideae, or Amaryllidaceae *sensu* Krause will have to wait.

#### SUMMARY

The ovule is anatropous, bitegmic, and crassinucellate. The inner integument consists of two, the outer of four to five, layers of cells. The micropyle is formed by the inner integument only, but after fertilization the outer integument elongates considerably and forms a characteristic protrusion toward the placenta. Periclinal walls occur in the nucellar epidermis, but the bulk of the nucellus is produced from the original subepidermal cells. At the time of fertilization, the massive nucellus is one-and-a-half times as long as the embryo sac and completely surrounds it. A parietal tissue of several cells is present. Embryo sac development is according to the *Polygonum* type. The endosperm is helobial.

Numerous differences in embryologic characters exist between *Muilla* and the other genera of the Allieae that have been investigated in this respect. Probably *Muilla* is more distantly related to these members of the Allieae than is realized at present. Embryologically, *Muilla* shows similarity with several genera of the subfamilies Melanthioideae, Asphodeloideae, Scilloideae, and Aletroideae of the Liliaceae, and with genera of the family Amaryllidaceae *sensu* Krause.

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## THE GENUS *TIARELLA* IN WESTERN NORTH AMERICA

PATRICIA KERN

This paper treats the three western North American taxa of *Tiarella*, a genus of the Saxifragaceae which is distinguished by two unequal valves of the dehiscent fruits and panicles of white flowers. These taxa have previously been treated as distinct species, recognizable by the basal leaf conformation. Study of the complex by analysis of population samples, field observations, and experimental breeding clearly indicates that there is continuous variation among the three. Their recognition as elements of one species complex, *T. trifoliata* L. is proposed. Within this species, two subspecies, ssp. *unifoliata* and ssp. *trifoliata* with two varieties, var. *trifoliata* and var. *laciniata*, are recognized.

**DISTRIBUTION.** The most widely distributed of the three, ssp. *unifoliata* has its eastern boundary in western Alberta and western Montana. From Alaska it extends southward, along both sides of the Cascade range, to the Santa Cruz Mountains in California. In California, it grows as low as at 150 feet elevation, whereas in most other areas it is found growing in moist forests in the mountains above 2000 feet.

Subspecies *trifoliata* is centered primarily west of the Cascade Mountains in Washington, but extends from Alaska to southern Oregon and to eastern British Columbia, and is found in scattered localities in western Montana, Idaho, and eastern Washington. It occurs in unmixed stands in western Washington at elevations less than 1500 feet.

Subspecies *trifoliata* and *unifoliata* both occur, mostly at altitudes that are mutually exclusive, along the western slopes of the Cascade range from Skamania Co. to Whatcom Co. in Washington and also in southwestern and eastern British Columbia. The ranges of the two, however, often overlap above 1500 feet elevation. Between 1500-2000 feet, ssp. *trifoliata* seems to be the more frequent, whereas ssp. *unifoliata* is the more frequent above 2500 feet. In their area of overlap, intergradient plants are evident.

Variety *laciniata* is narrowly limited to Vancouver Island, and to the San Juan and other adjacent islands of Puget Sound. Plants which closely approximate var. *laciniata* occur sporadically with mixed populations of ssp. *trifoliata* and *unifoliata* on the mainland. Variety *laciniata* appears always to be sympatric with var. *trifoliata*.

**CYTOLOGY AND HYBRIDIZATION.** All three taxa were found to have a gametic chromosome number of 7.

Controlled pollinations gave evidence that all were self-compatible, although none was spontaneously self-pollinating. All possible crosses resulted in fruits in percentages ranging from 40-65% (in 1963) or 45-88% (in 1964). Reciprocal crosses between var. *trifoliata* and var. *laciniata* yielded especially high percentages of fruit set (Kern, 1964).

No differences in the embryo and endosperm, or in seed-size, could be detected between seeds collected in the field and those produced by artificial pollinations. However, neither the seed produced from artificial pollinations nor that collected in the field germinated, possibly because it was stored for five months before planting. Numerous seedlings were observed in the field, so apparently germination readily occurs in the natural populations.

**MORPHOLOGICAL STUDY OF THE LEAVES.** Local population samples of 30–100 mature plants were taken from fifteen different locations in the Northwest. The plants were pressed in the usual manner but were left unmounted. The collections were used in the following ways: 1, for a series of simple leaf measurements; 2, for the portrayal of variability within a single population, 10–15 extreme and intermediate forms from each population were photographed; 3, for the construction of polygonal graphs showing intra- and inter-population variation of leaf pattern; and 4, for the construction of a bar graph designed to detect hybridization between the extreme forms (Anderson, 1941).

1. *Leaf-sinus measurements.* In order to obtain a precise assessment of morphological differences, a series of linear (fig. 1) and vein-angled measurements was made on the three largest basal leaves from each dried plant. The method of measuring the depth of lobation was an indirect one of measuring the length of the line forming a right angle with the midrib and extending straightway to the base of the sinus between the lobes. Approximately fifty plants per population (150 leaves) were measured.

The measurements of depth of lobation (numbers 10, 11, and 12 in fig. 1) were the only ones that might be interpreted to indicate a discontinuity between taxa. Measurement number 12, the depth of the sinus which splits the single leaf into three leaflets with distinct petiolules, readily separates the unifoliate from the trifoliolate plants even though there is a continuous gradation in the depth of the sinus (Kern, 1964). No true discontinuity exists in the increasing depth of the sinuses between the lobes of the unifoliate leaves and the spaces which these sinuses ultimately become in those plants with trifoliolately compound leaves. The critical mean leaf-sinus measurements, nos. 10–12 (fig. 1), are given in Table 1. All measurements are given in centimeters.

2. *Variability within populations.* Although unmixed populations of either ssp. *trifoliata* or *unifoliata* showed some variation from leaf to leaf, any one of the leaves in each could be readily identified as belonging to one or the other of these two taxa.

Populations with mixtures of plants with unifoliate, trifoliolate, and lacinately incised leaves presented a more complex problem. Nine mass collections of 30–100 plants were made along the western slopes of the Cascade Range from Mt. Rainier National Park north to Mt. Baker National Forest. Four of these will be reviewed below (Kern, 1964).

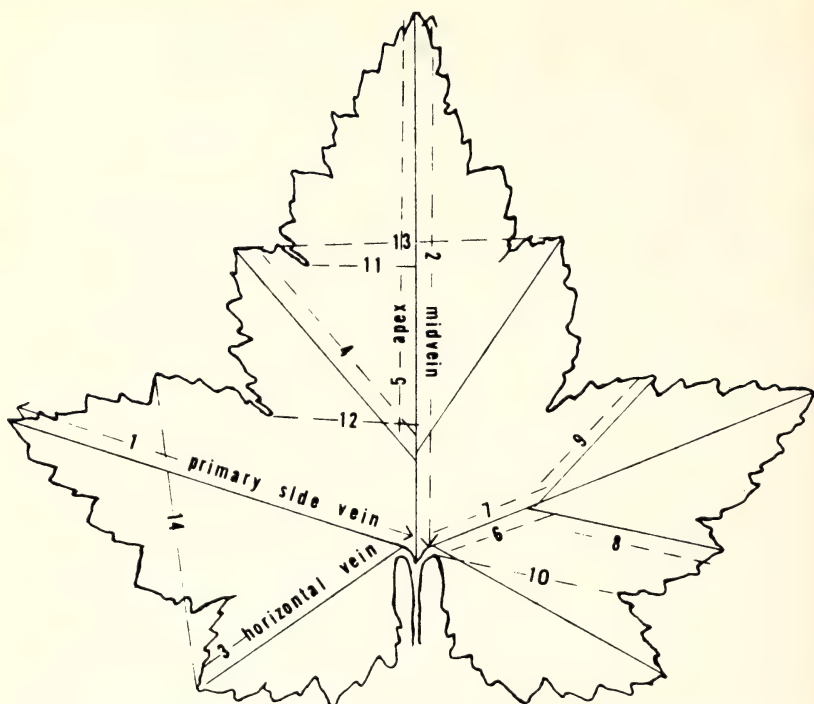


FIG. 1. *Tiarella* leaf showing measurements and enumerations used.

Plants of Denny Creek, about five miles west of Snoqualmie Pass, Washington, were representative of a population where the unifoliate phase was the most frequent. In the mass collection, 24 plants could definitely be called ssp. *unifoliata*, 12 ssp. *trifoliata*, 2 var. *laciniata*, and 13 intermediate between ssp. *trifoliata* and *unifoliata*. The plants that were considered intermediate all had some indentation toward the midvein. The range was from a slight indentation to a lobation as deep as that seen in plants misidentified as *T. trifoliata*, even though the apical and lateral lobes do not have distinct petiolules. Plants with such deeply dissected leaves are comparable to those that Lakela (1937) refers to as *T. unifoliata* f. *trisecta*, since they are very deeply dissected toward the midvein, but without distinct petiolules. All plants without distinct petiolules are considered here as unifoliate rather than trifoliate phases.

There were a few plants in this population that could be called var. *laciniata*, although they had larger and less-deeply dissected leaves than those characteristic of var. *laciniata* of the San Juan Islands.

Mixed populations of ssp. *unifoliata* and ssp. *trifoliata* which were linked by intergradient forms were found in numerous locations, only three of which are pictured (fig. 2 A-C).



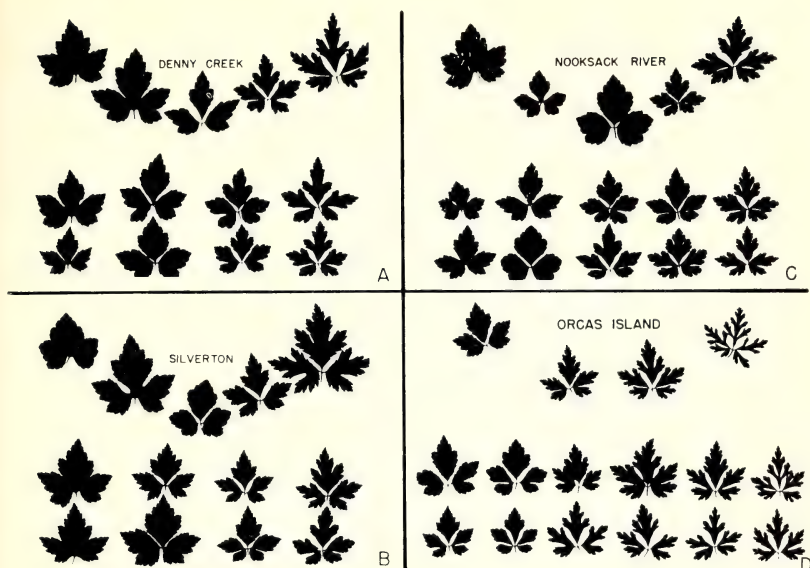


FIG. 2. Leaf outlines showing the range of variation within the population. The leaves in the upper two corners represent the extreme phases with intergradient forms between. The bottom two rows represent a portion of the variability within the population: A, Denny Creek, King Co., Wash.; B, Silverton, Snohomish Co., Wash.; C, Nooksack River, Skagit Co., Wash.; D, Orcas Island, Island Co., Wash.

The variation in leaf character becomes greatly complicated in the San Juan Island populations. On Whidbey I. and Orcas I., var. *laciniata* occurs in almost equal numbers with var. *trifoliata* in the moist woodland. On Orcas I. (fig. 2D), there are so many intergradient forms that the majority do not fit in either category.

3. *Intra- and inter-population variation of leaf pattern.* The variation within a population may be portrayed by the polygonal graph method (Davidson, 1947). As stated by Davidson, the graph "consists of a circle, with as many radii as there are characters to be compared. The characters, measured along each radius, are assigned absolute, relative, or arbitrary values. The characters possessed by each specimen are plotted along each radius, and the points are joined" (fig. 3A). By the overlap, or non-overlap, of the separate polygons on each graph, one can determine continuous or non-continuous variation. This would indicate whether a population contains two or more segregates or merely one variable entity. Eight characters, either absolute or relative, are graphed in fig. 3B-D.

Figure 3B, as indicated by the normal distribution (Davidson, 1947) on all radii, shows very little variability in an unmixed population of subsp. *unifoliata*. Polygons of a mixed population of var. *trifoliata* and

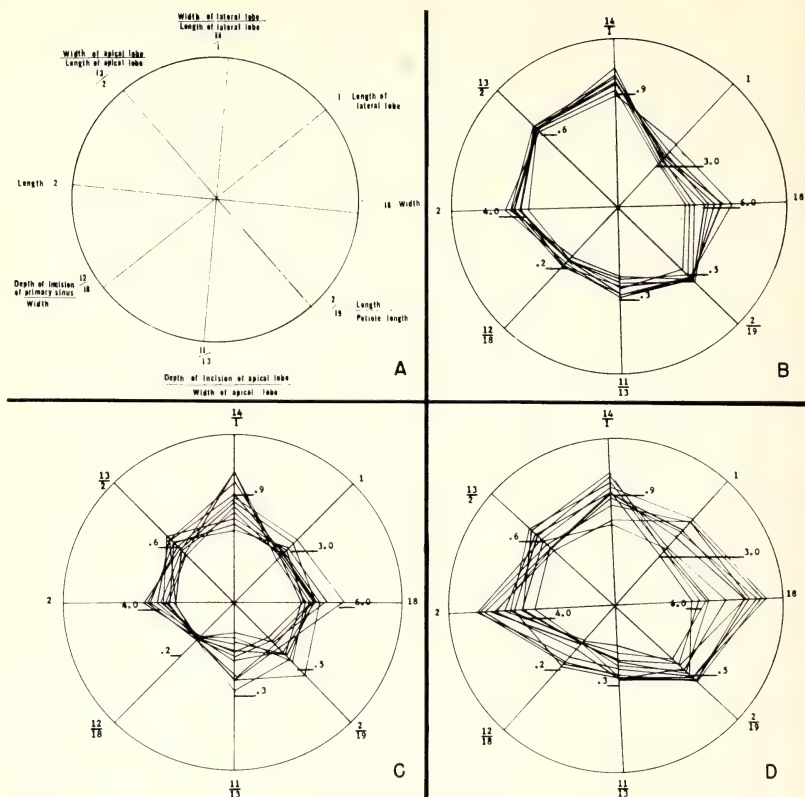


FIG. 3. Polygonal graphs for comparison of patterns of several characters: A, form used for the polygonal graphs, showing the basis for the graphing of eight characters; B, unmixed populations of ssp. *unifoliata*; C, mixed population of var. *trifoliata* and var. *laciniata*; D, mixed populations of ssp. *unifoliata*; ssp. *trifoliata*, var. *trifoliata*, and var. *laciniata*.

var. *laciniata* from Orcas I. (fig. 3C) show normal variability on all radii, indicating that there are numerous intergradient forms from one extreme (the trifoliolate phase) to the other (the laciniate phase).

A single mixed population from Denny Creek is graphed in fig. 3D. The variability on the radii for depth of primary sinus/width (12/18) and depth of incision of apical lobe/width of apical lobe (11/13) indicates the total range of variation within the population. From this and other patterns of continuous variation, it is evident that the mixed populations form one variable entity.

4. *Hybrid index*. The hybrid index presents the tabular data in a single figure. To each of three leaf measurements an index number was assigned (table 2). The numbers were then totaled to obtain the index value. The bar graph (fig. 4) was constructed with these values plotted against their frequency within the populations.

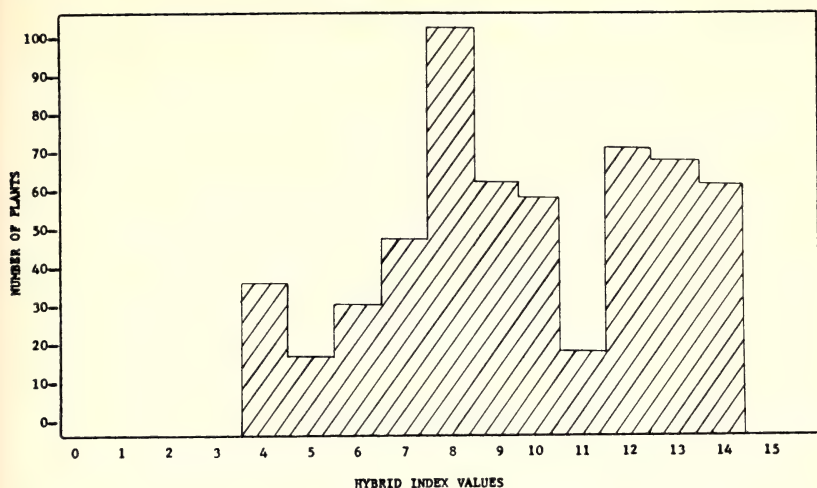


FIG. 4. Bar graph of hybrid index values for the taxa of *Tiarella*.

The index value of 4 is typically that of var. *laciniata*, 8 that of var. *trifoliata*, and 14 that of ssp. *unifoliata*. It can be seen that three peaks, at 4, 8, and 12–14 occur. There is a distinct decrease of frequencies at index value 11; intermediates at this value are not as numerous as those more closely resembling either the trifoliolate extreme (8) or the unifoliolate extreme (12–14).

No sharp decrease of frequencies between index values 4 and 7 can be noted; the range of variation from var. *laciniata* to var. *trifoliata* appears to be continuous.

**TAXONOMIC CONSIDERATIONS.** As shown by controlled breeding experiments and by strong circumstantial field evidence, the taxa of *Tiarella* are freely interbreeding. The flower and fruit structures of the taxa are indistinguishable. The various and variant attributes of leaf morphology remain as the only bases for assessing discontinuities. From the evidence presented above, no sharply discontinuous variation can be found. Therefore, I consider the western populations of *Tiarella* to constitute a single polymorphic species—*T. trifoliata* L.

The partial discontinuity in geographical distribution and morphology is sufficient, however, to justify the recognition of infraspecific elements. The unifoliolate and trifoliolate taxa of *Tiarella* are here considered to be of subspecific rank. Each occupies a major geographical area of the species range, and the two have an area of overlap, at elevations ranging between 2000–4500 feet, where they intergrade more or less completely.

The laciniolate-leaved phase, var. *laciniata*, occurs sporadically with mixed populations on the mainland but occurs in approximately equal numbers with the trifoliolate phase in insular populations. It, as found on the mainland, is possibly simply the result of recurrent and sporadic

TABLE 1. LEAF-SINUS MEASUREMENTS FOR THE TAXA OF *TIARELLA*

Taxa	No. of plants	Measurement Number					
		10		11		12	
		mean	range	mean	range	mean	range
<i>ssp. unifoliata</i>	24	2.1	1.3-2.6	1.1	0.5-1.6	1.5	0.8-2.1
	(Denny Cr.)						
	24	1.8	1.1-2.2	0.9	0.6-1.2	1.3	0.9-1.8
	(Silverton)						
Intermediate	10	1.8	1.0-2.2	1.0	0.5-1.3	1.3	0.8-1.6
	(Nooksack R.)						
	13	2.2	1.9-3.0	1.0	0.7-1.2	0.4	0.1-0.9
	(D.C.)						
	9	2.1	1.7-2.5	1.1	0.8-1.2	0.4	0.1-0.9
	(Sil.)						
	9	1.3	1.1-1.7	0.6	0.6-0.7	0.4	0.2-0.6
	(Nook.)						
<i>var. trifoliata</i>	12	1.0	0.6-2.6	0.6	0.4-0.9	0	
	(D.C.)						
	15	1.0	0.6-1.5	0.7	0.4-0.9	0	
	(Sil.)						
	36	1.2	0.4-2.4	0.7	0.5-1.2	0	
	(Nook.)						
	25	1.3	0.7-1.7	0.5	0.4-0.8	0	
	(Orcas Island)						
<i>var. laciniata</i>	2	0.1		0.3		0	
	(D.C.)						
	2	0.8	0.4-1.3	0.4	0.3-0.6	0	
	(Sil.)						
	2	0.6	0.3-0.8	0.4	0.3-0.5	0	
	(Nook.)						
	25	0.1	0.1-0.5	0.1	0.1-0.2	0	
	(O.I.)						

recombination of recessive genes. These individuals are of limited occurrence in a population and apparently cannot establish themselves as a major segment of the species.

Therefore, in *T. trifoliata* L., two subspecies are recognized: *ssp. trifoliata*, with two varieties, *trifoliata* and *laciniata* (Hooker) Wheelock, and *ssp. unifoliata* (Hooker) Kern. The appropriate new combination is hereby proposed.

SYSTEMATICS. *TIARELLA TRIFOLIATA* L. Sp. Pl. 406. 1753.

*Blondia trifoliata* Raf. Fl. Tell. 2:75. 1836. *T. rhombifolia* Nutt. in Torr. & Gray, Fl. N. Am. 1:588. 1840. (*G. Demidoff*, "Habitat in Asia boreali".) According to Hultén (Fl. of Alas. and Yukon 5:943. 1945) the actual type was: *Steller*, Cape St. Elias, Kayak I., Alas.

*T. stenopetala* Presl, Rel. Haenk. 2:55. 1831. (*Haenke*, "Nootka-Sund".)

*T. trifoliata* var. *laciniata* (Hook.) Wheelock, Bull. Torrey Club 23:72. 1896. *T. laciniata* Hook. Fl. Bor. Am. 1:239. 1832. *Petalosteira laciniata* Raf. Fl. Tell. 2:74. 1836. (*Menzies*, "North-West coast of America".)



TABLE 2. HYBRID INDEX VALUES

Character	Range	Index Number
Depth of incision of apical lobe (measurement #10)	0.1-0.2	1
	0.3-0.9	2
	1.0-1.6	3
	1.7-3.0	4
Depth of incision of lateral lobe (measurement #11)	0.1-0.2	1
	0.3-0.4	2
	0.5-0.9	3
	1.0-1.7	4
Depth of incision between primary and lateral lobes (measurement #12)	0	2
	0.1-0.9	4
	1.0-2.0	6

*T. trifoliata* ssp. **unifoliata** (Hook.) Kern, com. nov. *T. unifoliata* Hook. Fl. Bor. Am. 1:238. 1832. *Petalosteira unifoliata* Raf. Fl. Tell. 2:74. 1836. *Heuchera californica* Kell. Proc. Calif. Acad. 5:53. 1873. *T. unifoliata* var. *procera* A. Gray, Bot. Calif. 1:199. 1876. *T. trifoliata* var. *unifoliata* Kurtz, Bot. Jahrb. 19:378. 1894. *T. californica* Rydb. N. Am. Fl. 22:118. 1905. (*Drummond*, "Height of land in the Rocky Mountains, near the source of the Columbia, and at Portage River")

*T. unifoliata* f. *trisecta* Lakela, Am. Jour. Bot. 24:350. 1937. (*Butters & Holway* 216c, Beaver Valley, Alta.) = ssp. *unifoliata*.

Perennial, rhizomatous herbs; flowering stems 10-60 cm high; cauline leaves 2-3, short-petioled; basal leaves simple to compound; inflorescence paniculate; flowers white, sometimes with a pinkish tinge; sepals 5, oblong to triangular, 2-5 mm long, somewhat irregular, the hypathium short-campanulate,  $\frac{1}{4}$ - $\frac{1}{2}$  as long as the lobes, almost free of the ovary; petals 2-5 mm long, subulate, almost indistinguishable from the filaments; stamens 10, 2-6 mm long, those opposite the petals the shorter; pistil 1-celled, with two parietal and nearly basal placentae; valves of the capsule unequal, the upper one  $\frac{1}{3}$  as long as the lower; seeds 1.5-2.0 mm, black, shining and smooth, the raphe prominent. The species consists of two subspecies and two varieties as follows:

Leaves simple, 4-12 cm broad, 2.5-7.0 cm long (including those plants with leaves dissected to within 0.1 cm of the midvein but without distinct petiolules)

ssp. *unifoliata* (Hook.) Kern

Leaves compound, 2-12 cm broad, 2.5-7.0 cm long.....ssp. *trifoliata*

Leaflets laciniately cleft, the lateral pair deeply dissected to within 0.1-0.4 cm of the midvein, the middle one dissected to within 0.1-0.9 cm of the midvein; occurring as a sporadic variant with ssp. *unifoliata* and ssp. *trifoliata* and sympatrically with ssp. *trifoliata* on Vancouver Island and adjacent islands of Puget Sound.....var. *laciniata* (Hook.) Wheelock

Leaflets not laciniately cleft, the lateral pair shallowly lobed to lobed within 0.5 cm of the midvein, lobes of the middle leaflet dissected to within 1.0 cm of the midvein; occurring primarily west of the Cascade Range in Washington, but ranging from Alaska to Oregon and east to eastern B.C.....var. *trifoliata*

Department of Botany, University of Washington, Seattle

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## NOTES AND NEWS

**OCCURRENCE OF THE GENUS EUPHRASIA IN THE PACIFIC NORTHWEST.**—The genus *Euphrasia* has not previously been reported from Washington. Now, *E. canadensis* Townsend has been collected in Parkland, near Tacoma, Pierce Co., Washington, where it is locally abundant in a moist grassy area adjacent to a small swamp one-half mile east of the intersection of state highways 5 and 512 (*Ganders 135*, WS). *Euphrasia canadensis* is almost certainly introduced at Parkland, and the fact that another localized species, *Viola lanceolata* L., occurs with it suggests the possibility of the same mode of introduction. *V. lanceolata* was introduced in the early twentieth century with importations of cranberry plants from New England and Wisconsin (Schultz, J. H., *Madroño*. 8:191-193. 1946), and since *E. canadensis* occurs in New England this same thing could have occurred. However, if this is the case, it is surprising that the plant has not been collected before in Washington, as *V. lanceolata* was detected in 1936 (Jones, G. N., *Madroño*. 4:34-37. 1937). Another record for *Euphrasia* that should be noted is a collection of *E. americana* Wettst. from Qualicum, Vancouver I., British Columbia (on golf links, *Redfern*, WS). This species was not included in *Vascular Plants of the Pacific Northwest*.—FRED R. GANDERS, Washington State University, Pullman.

**HERBARIUM SUPPLIES.**—Bonestell & Co., of San Francisco, for many years a supplier of herbarium supplies, has recently been forced to go out of business. The line of herbarium supplies developed by Mr. Cyril A. Cross, in consultation initially with Dr. LeRoy Abrams and Dr. W. L. Jepson, is now available through the Commercial Paper Corp., 300 Brannon St., San Francisco, California 94107. Mr. Cross will handle these supplies at the Commercial Paper Corp. and he has indicated that the same high standards will prevail and that the prices will be the same as they were as of September 15, 1965.



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## VARIETAL TRANSFERS IN CUPRESSUS AND CHAMAECYPARIS

ELBERT L. LITTLE, JR.

Four species of *Cupressus* L. (cypress) are transferred here as varieties of *C. arizonica* Greene (Arizona cypress), and a recently described species of *Chamaecyparis* Spach (white-cedar) is reduced to a variety. A review of the New World species of these two genera of Pinaceae has been made while distribution maps were being revised.

### CUPRESSUS

In a comprehensive monograph of the New World species of *Cupressus* based on studies of wild and cultivated plants, Wolf (1948) accepted 15 species (12 in the United States), one with two subspecies. Two species and one subspecies were proposed as new.

Discussing the specific concepts, Wolf (1948) agreed with W. L. Jepson that the species rest on rather insecure morphological features. His key to species illustrated the scarcity of well-defined qualitative morphological characters. Many characters used, such as color of foliage, size of parts, and bark, would not be of specific value in related genera. As Wolf observed, there has been confusion in taxonomic literature of *Cupressus* and disagreements on ranks and synonymy. And the same author has changed his concepts.

Wolf concluded that this very old group of species once occupied larger areas but in later times, either through climatic changes, diseases, or competition, had been reduced to the present minor role in the vegetation. The range of each species is discontinuous, consisting usually of a few isolated groves or stations which can be counted.

Twisselman (1962) has suggested that *C. nevadensis* Abrams, of Kern Co., California, is a remnant of a once widespread complex in the arid woodland occurring across the Mojave Desert until late Pliocene. This species has been progressively restricted by increasing aridity and associated factors and now survives precariously. He noted that *C. mohavensis* Axelrod (Carnegie Inst. Wash. Pub. 516:86. 1939), a Miocene species related to *C. arizonica*, was found nearby. It seemed tenable that geographic isolation could account for the differences between *C. nevadensis*, *C. arizonica*, *C. forbesii*, and *C. montana*.

Earlier, Sargent (1926) described and figured for the United States six species and one variety of *Cupressus*. My conservative compilation accepted six species without varieties (Little, 1953), to which should be added *C. sargentii* Jeps., of California, and the five varieties below. The other New World species, *C. lusitanica* mill. (*C. benthamii* Endl., *C. lindleyi* Klotzch), is native from Mexico to Honduras.

*CUPRESSUS ARIZONICA* Greene. Three species cited also as synonyms (Little, 1953) and another from Baja California are transferred here as varieties. The summary key below to the five varieties is adapted from Wolf (1948). The combined range extends from Chisos Mountains, Trans-Pecos Texas, to central Arizona and southern California, and also to northern Mexico (Baja California and from Sonora to Tamaulipas, south to San Luis Potosí, Zacatecas, and Durango).

*CUPRESSUS ARIZONICA* var. *ARIZONICA*. *C. arizonica* Greene, Bull. Torrey Club 9:64. 1882. *C. arizonica* var. *bonita* Lemm., Handb. W.Amer. Cone-Bearers. Ed. 3. 76. 1895. *C. arizonica* var. *bonito* Lemm., Sierra Club Bull. 4:118. 1902. *C. benthamii* Endl. var. *arizonica* (Greene) Mast., Jour. Linn. Soc. Bot. 31:340. 1896. *C. arizonica* f. *glomerata* Martinez, Anal. Inst. Biol. Mexico 18:129. 1947. *C. arizonica* f. *minor* Martinez, Anal. Inst. Biol. Mexico 18:133. 1947.

The type of *C. arizonica* was collected by Edward L. Greene "on the mountains back of Clifton," Greenlee Co., Arizona (isotype, NA!). Lemmon (1895) distinguished also var. *bonita*, with "trunk and limbs not the least decorticated," abundant and of large size in Bonita Canyon, Chiricahua Mountains, now in Chiricahua National Monument. This variety was afterwards united with *C. glabra* Sudw. but was reduced to synonymy of *C. arizonica* by Kearney and Peebles (1942). Variety *arizonica* is native from Chisos Mountains, Texas, to south-eastern Arizona and in northern Mexico.

In his monograph of the Mexican species, Martinez (1947) named two forms as new, *C. arizonica* f. *glomerata* and f. *minor*.

*CUPRESSUS ARIZONICA* var. *glabra* (Sudw.) Little, comb. nov. *C. glabra* Sudw., Am. Forestry 16:88, fig. 1910 Feb.

This variety is native in central Arizona from Oak Creek Canyon, Coconino Co., to Mazatzal Mountains, Gila Co. George B. Sudworth (1910), dendrologist of the Forest Service and predecessor agencies of the U. S. Department of Agriculture from 1886 until his death in 1927, published the original description with a photograph of twig and cones but without citation of specimens. In December 1909, he studied this tree at Verde River Canyon in Yavapai Co., Arizona. The specific epithet presumably referred to the "very thin smooth, dark purple-red bark." Also, the "perfectly smooth bark" was contrasted with the rough bark of *C. arizonica*, "characterized by a rather thin, somewhat stringy, anastomosely furrowed bark of dark red-brown color." Earlier, Toumey (1895) had observed at Natural Bridge the trees with different reddish, peeling bark.

Recently I have found Sudworth's type specimen among several black cardboard boxes of bulky unmounted conifers in storage. One lot, considered the holotype, consists of several unpressed twigs with mature cones and male strobili and two seedlings, mostly bearing tags "*Cupressus glabra* GBS" and negative numbers. A note contains the name *Cupressus* n. sp., changed to *Cupressus glabra*, "Verde Canyon, Pres-

cott N. Forest 12/29/09 GBS." The exact locality, apparently added later and shown also on specially prepared maps in the map file, was "From Tinsley's Ranch approx. T. 11 N., R. 6 E., Sec. 17 (NW  $\frac{1}{4}$  of NW  $\frac{1}{4}$ )." A second lot of undated specimens with two pieces of reddish brown smoothish thin bark is labelled "from W. A. Tinsley, Prescott Natl. Forest, Verde River Canyon (Type locality)." Another lot, with two pieces of slightly rough bark, from Natural Bridge, Arizona, received Sept. 17, 1910, had the name *C. glabra* changed to *C. arizonica*. The first lot, the one element used by the author, is the holotype. It has been divided and distributed as indicated by the citation: *George B. Sudworth Dec. 29, 1909*, William A. Tinsley's Ranch, Sec. 17, T. 11 N., R. 6 E., Verde Canyon, 16 mi. SE. of Camp Verde, Yavapai Co., Arizona (US—holotypus, A, ARIZ, RSA, USFS). The type locality is now within the Tonto National Forest.

Sudworth (1915) described, illustrated, and mapped both *C. glabra* and *C. arizonica*. However, the maps (maps 1, 2) showed both occupying nearly the same ranges in Arizona. His plate 3, a line drawing copied from a photograph, illustrated two large trunks touching at the base and with this legend: "Cupressus arizonica (right) with characteristic furrowed bark, Cupressus glabra (left) with smooth scaly bark." It was reported that a forester had submitted this photograph to show that only one species was represented. As now interpreted, the two taxonomic groups native in Arizona have separate ranges, and both trunks would be within the variation of var. *glabra*, which sometimes develops furrowed bark on very large trunks.

While working in Arizona from 1935 to 1941, I learned of the uncertainty among local foresters whether there were one or two species of *Cupressus*. I reduced *C. glabra* to synonymy (Little, 1944), stating that the two were separated only by bark characters and different range. Wolf (1948) noted that the foliage of *C. glabra* was usually much grayer. Variety *glabra* is more ornamental than the typical variety because of its smoothish bark and grayish foliage and is much commoner in cultivation under the names *C. arizonica* and var. *bonita*.

Two varietal epithets were given to horticultural varieties, in Europe, but their correlation with wild trees is uncertain. *Cupressus arizonica* var. *compacta* C. K. Schneid. (*Silva Tarouca*, Uns. Freil.-Nadelh. 174, 1913) was a low roundish bush. *Cupressus arizonica glauca* Woodall (*Garden* 80:16, 1916) was a juvenile form of silvery gray foliage. Both were accepted as varieties by Rehder (Bailey, 1923; 1933; Rehder, 1940) but were reduced to forms later by Rehder (1949). Krüssmann (1960) reduced them to horticultural varieties (cultivars).

Bannan (1954) found *C. arizonica* and *C. glabra* to have similar wood structure but did not study the other three species of this group.

CUPRESSUS ARIZONICA var. **montana** (Wiggins) Little, comb. nov. *C. montana* Wiggins, Contr. Dudley Herb. 1:161. 1933.

An isotype of this variety from Sierra San Pedro Martir, northern



Baja California, *Wiggins & Demaree 4990* (US), has been examined. Wolf (1948) noted a relationship with *C. arizonica*.

*CUPRESSUS ARIZONICA* var. **nevadensis** (Abrams) Little, comb. nov. *C. nevadensis* Abrams, *Torreyia* 19:92. 1919. *C. macnabiana nevadensis* (Abrams) Abrams, *Illus. Fl. Pacif. States* 1:73. 1923.

Wolf (1948) observed that *C. nevadensis* has its closest affinities with *C. arizonica*. This variety is known from a few groves in Piute Mountains, Kern Co., California.

*CUPRESSUS ARIZONICA* var. **stephensonii** (Wolf) Little, comb. nov. *C. stephensonii* Wolf, *Aliso* 1:125. 1948.

This variety, the rarest of the named cypresses, is known from a single grove in Cuyamaca Mountains, Cleveland National Forest, San Diego Co., California. It was noted there by the late Ranger J. Bert Stephenson, whose specimen is deposited in the Forest Service Herbarium. According to Wolf (1948), *C. stephensonii* is somewhat intermediate between *C. glabra*, which it resembles in its smooth, exfoliating bark, and *C. arizonica*, in its much less glandular leaves.

Trunks of mature trees with rough, furrowed, gray or dark brown bark.

Cones opening at maturity; leaves with active gland; San Pedro

Martir, Baja California.....var. *montana*

Cones usually remaining closed for several seasons.

Leaves with inactive or occasionally active gland or sometimes none; southeastern Arizona to Chisos Mountains, Texas, and northern Mexico.....var. *arizonica*

Leaves with conspicuous, active gland; Piute Mountains, Kern

Co., California.....var. *nevadensis*

Trunks of mature trees with smooth, cherry-red or mahogany-brown bark, peeling in thin, curling plates.

Leaves with comparatively inactive gland; seeds mostly more than

5 mm. long, not glaucous; Cuyamaca Mountains, San Diego

Co., California.....var. *stephensonii*

Leaves with very active gland; seeds mostly 4–5 mm. long, glaucous;

central Arizona.....var. *glauca*

#### CHAMAECYPARIS

Three species of *Chamaecyparis* Spach have long been accepted for North America, two western and one eastern. *Chamaecyparis nootkatensis* (D. Don) Spach is native in the Pacific Coast Region from southeastern Alaska to northwestern California. *Chamaecyparis lawsoniana* (A. Murr.) Parl. has a limited range in southwestern Oregon and northwestern California.

*Chamaecyparis thyoides* (L.) B. S. P. is found in the Atlantic and Gulf Coastal Plains, especially in swamps, from southern Maine to northern Florida and west to southern Mississippi. This Linnaean species without named geographical varieties is the lectotype of the genus (Britton & Shafer, 1908).



A segregate species proposed in 1962 is reduced here to a variety. Both geographic varieties summarized below, have separate, discontinuous ranges. A few horticultural varieties named in Europe apparently were derived from the typical, accessible, northern variety, which was introduced into Europe first. Rehder (1940; 1949) reduced four of these to forms.

CHAMAECYPARIS THYOIDES (L.) B. S. P., Presl. Cat. Anth. Pter. N. Y. 71. 1888, var. THYOIDES. *Cupressus thyoides* L., Sp. Pl. 1003. 1753.

Range. Atlantic Coastal Plain from Waldo Co. in southern Maine to Lexington Co. in central South Carolina and extinct along the Savanna River near Augusta, Georgia.

CHAMAECYPARIS THYOIDES var. **henryae** (Li) Little, comb. nov. *C. henryae* Li, Morris Arb. Bull. 13:43. 1962.

Range. Gulf Coastal Plain from Liberty Co. in northwestern Florida west through southern Alabama to Pearl River Co. in southern Mississippi. Also local in Taylor, Talbot, and Marion counties in western Georgia and in Putnam and Marion counties in northeastern Florida.

Li (1962) has published a detailed description of this segregate. The differences from the northern type include bark, color of foliage, size and position of leaves, glands of leaves, lower surface of juvenile leaves, color of male strobili, size, number of scales, and color of cones, size of seeds and wings, and time and appearance of male strobili. Li noted that Bartram (1791) first observed in 1777 that the trees in southern Alabama differed a little from those of New Jersey and Pennsylvania.

Like the differences between some geographically separated populations of *Cupressus*, these characters seem to me to represent two geographical varieties of one species. The original description suggested somewhat closer relationship of the new species with the western species *C. nootkatensis* than with *C. thyoides*. Ward (1963) remarked that "such speculations merit further investigation." *Chamaecyparis nootkatensis* differs from typical *C. thyoides* and its segregate in having stout 4-angled twigs, closely appressed larger obtuse leaves, usually without glands, cones almost twice the size and scales with more prominent points, and larger seeds with broader wings. In sterile specimens the stout foliage sprays of *C. nootkatensis* are readily distinguished from the fine foliage sprays of both typical *C. thyoides* and its segregate.

Mrs. Mary Gibson Henry, President of the Henry Foundation for Botanical Research, Gladwyne, Pennsylvania, has made intensive field studies of the var. *henryae*. When first collecting specimens in 1939, she noted the differences from the northern trees. She has made several special field trips to make detailed collections throughout the geographic range.

I am indebted to Mrs. Henry for a duplicate set of her extensive collections of 1962-63 totaling 56 numbers (NA) of var. *henryae* including an isotype (*M. G. Henry* 7108 (23), NA, US, Perdido River, Barrineau Park, Escambia Co., Florida) and collections from eight counties of

Florida, three counties of Georgia, four counties of Alabama, and two counties of Mississippi.

The trees are found in privately-owned forests along streams and in swamps. Li reported that large trees are now extremely rare and that extensive logging has greatly reduced the number of stands and large specimens. However, small trees are fairly plentiful along streams and in less accessible swamps, according to Mrs. Henry's labels.

Specimens from two isolated stations in northeastern Florida are referred to var. *henryae*, having mostly five cone scales instead of six and bearing male strobili in the autumn instead of the spring. Ward (1963) has reported on the well-known station four miles south of Interlachen, Putnam Co., and the second stand about 30 miles east of Ocala on Juniper Creek along the boundary of Marion and Lake counties. The name Juniper Creek apparently refers to these trees, known locally as junipers. This stand at the southeastern limit of the species is within Ocala National Forest and is protected from cutting. It was brought to the attention of Ward in 1962 by Paul E. Bielling of the Florida Forest Service and formerly of the U. S. Forest Service. Bielling sent me specimens collected in Dec. 1963 (NA, US, USFS). Mrs. Henry collected specimens at both localities also.

Forest Service, U. S. Department of Agriculture, Washington, D. C.

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## ON THE SPECIFIC DISTINCTION OF ERIOGONUM NUTANS AND COLLINUM

JAMES L. REVEAL

While preparing a taxonomic revision of the *Eriogonum deflexum* Torr. complex, it became necessary to investigate the relationship of *E. nutans* Torr. & Gray to the complex. From the morphological standpoint, *E. nutans* somewhat resembles *E. parryi* A. Gray and *E. brachypodium* Torr. & Gray because of its glandular pubescence, and is similar to *E. hookeri* S. Wats. in its wide campanulate involucre and the general plant stature of the immature specimens of *E. hookeri*. However, *E. nutans* lacks the cordate base of the outer perianth segments typically found in these species, and is an octoploid rather than tetraploid like all of the members of the *E. deflexum* complex. The historical and morphological confusion, however, has been with the unrelated taxon, *E. collinum* S. Stokes ex M. E. Jones.

The type of *E. nutans* was collected by Beckwith from Mud Lake Valley, Washoe County, Nevada in 1854, and was originally described by Torrey and Gray (1855) as *E. cernuum* Nutt. var. *purpurascens*. In their revision of the genus (1870), they elevated the taxon to the species rank.

The inclusion of *E. nutans* into the California flora has been based on Watson's treatment of *Eriogonum* in Botany of California (1880), at which time he erroneously cited the Beckwith collection as coming from Lassen County. Jepson (1914), Abrams (1944), and Munz (1959) have all considered this species to be in California on the basis of this error. A recent review of herbarium material has revealed that *E. nutans* is not in California.

*E. collinum* was described in 1903 from a series of collections made by Stokes, Jones, and Hillman from the vicinity of Reno, Nevada. Until



now, four taxa described by M. Gandoger (1906) have been thought, by this writer and others, to be referable to *E. collinum*: *E. praebens* Gand., *E. praebens* var. *divaricatum* Gand., *E. reniforme* Torr. & Frem. var. *asarifolium* Gand., and *E. thurberi* Torr. var. *acutangulum* Gand. Jepson placed the California collection of *E. praebens* under the southern California and adjacent Nevada species, *E. reniforme* Torr. & Frem., without comment. Tidestrom (1925), possibly following Jepson's treatment, placed *E. praebens* under *E. reniforme*, and questionably referred *E. collinum* to that taxon. While Abrams did not handle *E. praebens* in any manner, Munz modified the problem slightly by placing the Gandoger species under *E. nutans*. When Stokes monographed the genus (1936), she referred *E. praebens* and the var. *divaricatum* to her species, but considered *E. reniforme* var. *asarifolium* as a synonym of *E. reniforme*, and made a new combination, *E. cernuum* Nutt. ssp. *acutangulum* for the last Gandoger taxon. The main reason for this assumption is that all of the Hillman specimens deposited at Reno, which bear the same location data as that given by Gandoger, are *E. collinum*, but the holotypes at Lyon, France, are not that species. *Eriogonum praebens* and var. *divaricatum* are *E. baileyi* S. Wats. var. *tomentosum* S. Wats., var. *asarifolium* is *E. pusillum* Torr. & Gray, and var. *acutangulum* is *E. maculatum* Heller. One Gandoger species not previously associated with *E. collinum* is *E. restioides*. The description was based mainly upon two plants of *E. baileyi*, but the leaf description is that of *E. collinum*, the left hand specimen on this mixed sheet.

The relationship of *E. collinum* to the other members of the Section *Pedunculata* Benth. in DC. is still obscure. The closest species to *E. collinum*, at least from a morphological and cytological standpoint, seems to be a taxon Stokes described as *E. demissum* S. Stokes. However this taxon, by our present subgeneric concept, is a member of the subgenus *Oregonium* S. Wats., rather than *Ganysma* S. Wats., and thus more work is necessary before the relationship of either taxa can be established.

During the summer of 1964, Noel H. Holmgren of the New York Botanical Garden and this writer made field observations on the two species, and obtained cytological material. Buds were collected from living specimens, and placed in Newcomer's Solution (1953). Anther smears were made using the iron-acetocarmine techniques, and counts were taken from temporary mounts of Telophase II. A tabular arrangement of the chromosome numbers and citation of specimens follows. All collections were made by N. H. Holmgren and J. L. Reveal.

*E. collinum* S. Stokes ex M. E. Jones.  $n = 18$ . Nevada, Humboldt Co., Leonard Cr., Pine Forest Range, 887; Correl Cr., Pine Forest Range, 1347; California, Lassen Co., Ravendale, 1723. Counted by J. L. Reveal.

*E. nutans* Torr. & Gray var. *nutans*.  $n = 40$ . Nevada, Humboldt Co., Quinn River Crossing, 1256. Counted by J. L. Reveal.

*E. nutans* var. *glabratum* Reveal.  $n = 40$ . Nevada, Elko Co., Deeth, 1037; Halleck, 1468. Counted by J. L. Reveal.



The results of this study are given in the following key and synopsis. To the curators of herbaria that were visited, or who have sent loan material for this study, the author is grateful.

## KEY

Peduncles curving upward, 1-3 (-5) cm long; involucre turbinate, greenish-yellow; perianth white with a yellowish cast, or yellow, strongly pustulose at the base, or rarely hirsutulous, the calyx-segments similar; achene glabrous; southwestern Idaho, northwestern Nevada, and adjacent northeastern California. *E. collinum*

Peduncles curving downward, 3-10 mm long; involucre campanulate, reddish or ashy-gray; perianth white with a reddish cast, becoming red, or yellow, weakly pustulose or glabrous at the base, the calyx-segments dissimilar; achene pubescent; west-central Nevada through central and northern Nevada to southeastern Oregon, and central Utah. .... *E. nutans*

Involucre and peduncles glandular, reddish; range of the species.

*E. nutans* var. *nutans*

Involucre and peduncles glabrous, ashy-gray; Elko Co., Nevada.

*E. nutans* var. *glabratum*

ERIOGONUM COLLINUM S. Stokes ex M. E. Jones, Contr. West. Bot. 11:15. 1903. Type: *S. Stokes s.n.*, Reno, Washoe Co., Nevada, June 19, 1900. (UC, isotypes NY, US). *E. restioides* Gand., Bull. Soc. Bot. Belg. 42:199. 1906. Type: Reno, *Hillman s.n.* (LY), *pro parte*. *E. nutans* of Watson, Bot. Calif. 2:23. 1880; Jepson, Fl. Calif. 1:409. 1914; Abrams, Ill. Fl. Pac. States 2:34. 1944; and Munz, Calif. Fl. 343. 1959, as to the name, not as to the type. *E. reniforme* of Tidestrom, Contr. U. S. Natl. Herb. 25:154. 1925, as to synonymy in part.

Annual; scapes one to several from or slightly above the caudex, (0.5-) 1-5 (-7) dm high, trichotomous at the first node, floccose at the base becoming glabrous at maturity; leaves basal, 1-2.5 (-3) cm long, 1-3 (-3.5) cm wide, round, cordate, elliptic, to obovate, the apex rounded, the base subcordate to reniform, sparsely hirsute to densely white tomentose below, subglabrous to glabrate, or glabrous above, leaf margins plane or crenulate; petiole 1-5 cm long, tomentose, becoming sparsely floccose to glabrous at maturity; bracts (1-) 1.5-3 (-4) mm long, subulate to lanceolate, ternate and connate at the base, glabrous to hispid within and without; branches dichotomous, glabrous, rather open and divaricated, often with an involucre—bearing peduncle in the node; peduncles curving or ascending upwards, the one or two peduncles in the upper forks occasionally straight, stoutish or slender, 1-3 (-5) cm long, glabrous; involucre turbinate (1.5-) 2-3 mm long, (1-) 1.5-2.5 mm wide, glabrous within and without, 5-lobed, the lobes acute, triangular and erect, dividing the tube  $\frac{1}{3}$  to  $\frac{1}{2}$  its length, bractlets white to yellowish, numerous, linear-oblongate, 1-2.5 mm long, sparsely hirsutulous with pointed marginal cells, pedicels glabrous, 2-4 mm long, 5 to 15 flowered; perianth white with a yellowish cast, to pinkish-

yellow, or yellow, the midrib pink to red-brown, pale green below the union of the outer calyx-segments, 1–2.5 mm long in anthesis, glabrous except for the pustulose or rarely hirsutulous basal portion of the perianth tube, calyx-segments similar, the lobes ovate, lanceolate to spatulate, margins of the segments often crispate, becoming somewhat revolute; stamens glabrous, included, 1–1.5 mm long, anthers greenish to yellow, or reddish; calyx-segments elongated in fruit; achene glabrous, fusiform, 2–2.5 mm long, tapering to a short 3-angled beak.  $n = 18$

**Distribution.** In the sandy valley bottoms and clayey foothills of the Reno and Carson City area north to Humboldt Co., Nevada, and adjacent Owyhee Co., Idaho, and eastern California from Sierra Co. north to Lassen Co. Flowering from June to September.

**Representative specimens.** CALIFORNIA. Lassen Co.: near Secret Valley, *Kelly in 1937* (CAS); near Termo, *True 912* (CAS); Bull Flat near Honey Lake, *True 784* (CAS); between Mapes and Secret Valley, *Heller 15208* (CAS, NY, POM, US, UTC); between Shaffer Mountain and Warren Peak, *Hoover 4645* (CAS, NY, US); Viewland, *Ripley & Barneby 5758* (CAS, NY); 0.4 mi S of Ravendale, *Raven & Solbrig 13293* (CAS);  $\frac{1}{4}$  mi S of road junction to Smoke Creek, along U. S. 395, *Bacigalupi & Constance 7136* (CAS); 1 mi S of Ravendale, *Cronquist & Holmgren 8478* (CAS, NY, UTC); 4 mi S of Ravendale, *N. Holmgren & Reveal 1723* (ARIZ, BRY, CAS, DS, GH, MO, NY, RENO, RM, RSA, SMU, UC, US, UT, UTC). IDAHO. Owyhee Co.: 13 mi SE of Bruneau, near Hot Creek, *Christ & Christ 16721* (NY). NEVADA. Humboldt Co.: Leonard Creek, Pine Forest Range, *N. Holmgren & Reveal 887* (ARIZ, BRY, CAS, DS, GH, KSC, MO, NY, RENO, RM, RSA, SMU, UC, US, UT, UTC); Corral Creek, Pine Forest Range, *N. Holmgren & Reveal 1347* (ARIZ, BRY, CAS, DS, GH, KSC, MO, NY, RENO, RM, RSA, SMU, UC, US, UT, UTC). Lyon Co.: 2.3 mi SE of Dayton, *Stackhouse 64* (UC). WASHOE Co.: Reno, *M. E. Jones in 1897* (US); Reno, *Heller 9711a* (CAS, RENO); Reno, *Eastwood 14775* (CAS); 2.3 mi NE of Sparks, *Raven 14286* (RSA); Peavine foothills, *J. T. Howell 38100* (CAS).

**ERIOGONUM NUTANS** Torr. & Gray, Proc. Am. Acad. 8:181. 1870. Annual; scapes one to several from or slightly above the caudex, 5–30 cm high, trichotomous at the first node, glabrous; leaves basal, 5–20 mm long, 5–25 mm wide, rounded to broadly reniform, the apex rounded, the base somewhat truncate, subcordate, or cordate, densely white tomentose below, floccose to glabrate above; petiole 5–25 mm long, tomentose, occasionally sheathing up the stem for as much as 1 cm; bracts 1–2 mm long, triangular, 2- or 3-parted, glandular or glabrous without, arachnoid pubescent or glabrous within; branches dichotomous, glandular or glabrous, open to diffuse, often with an involucre-bearing peduncle in the nodes; peduncles curving downward, or somewhat cernuous, slender, 3–10 mm long, glandular or glabrous; involucre campanulate, 2–3 mm long, 2–3.5 mm wide, glandular or glabrous within and without, 5-lobed, the lobes rounded, erect, dividing the tube to about  $\frac{1}{2}$  its length, reddish-brown with a white membranous margin, or ashy-gray, bractlets 1–1.5 mm long, linear-oblongate, minutely hirsutulous with capitate marginal cells; pedicels glabrous or sparsely glandular at the base, 2.5–3.5

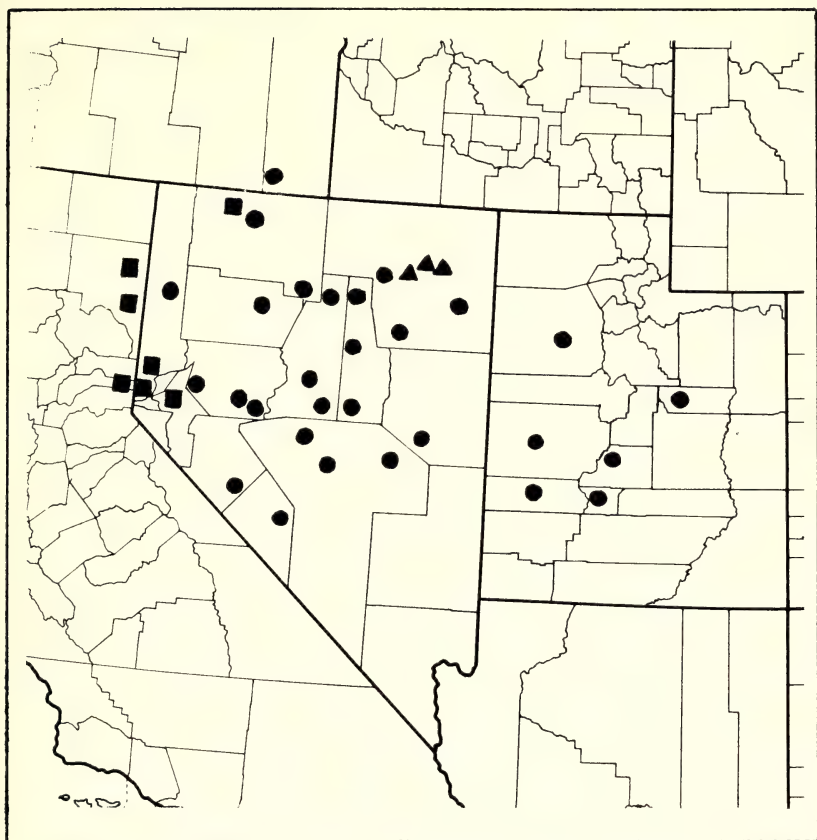


FIG. 1. Distribution of *E. collinum* (squares), *E. nutans* var. *nutans* (circles), and *E. nutans* var. *glabratum* (triangles).

mm long, 5 to 10 flowered; perianth white, rose, deep red, or yellow, 2–3 mm long in anthesis, weakly pustulose or glabrous on the basal portion of the perianth tube, calyx-segments dissimilar, the outer whorl oblong or oval, emarginate at the broad apex, obtuse at the base, the inner whorl narrower and shorter; stamens glabrous, 2–3 mm long, anthers green or red; calyx-segments elongated in fruit; achene pubescent with short appressed brownish hairs, 1.7–2 mm long, the subglobose base tapering to a long 3-angled beak.  $n = 40$ .

**ERIOGONUM NUTANS** Torr. & Gray var. **NUTANS**. Type: *Beckwith*, Mud Lake Valley, Washoe Co., Nevada, June 16, 1854, (NY, isotypes GH, photograph of this isotype at DS, UTC, additional isotype at MO). *E. cernuum* Nutt. var. *purpurascens* Torr. & Gray, Pacif. Railroad Report 2:124. 1855. *E. rubiflorum* M. E. Jones, Zoe 4:281. 1895. Type: Dugway, Tooele Co., Utah, May 28, 1891, *M. E. Jones s.n.* (POM,



isotypes, A, ARIZ, DS, MO, NY, UC, US). *E. nutans* var. *brevipedicellatum* S. Stokes, Gen. Eriog. 43. 1936. Type: 30 mi W of Eureka, Eureka Co., Nevada, August 25, 1931, *J. T. Howell* 7974 (CAS, isotype GH). *E. deflexum* Torr. in Ives ssp. *ultrum* S. Stokes, Gen. Eriog. 45. 1936. Type: Sevier Valley, Sevier Co., Utah, June 18, 1933, *Eastwood & Howell* 623 (CAS).

Peduncles and involucre glandular, reddish; plants 5–20 cm high; range of the species.

Distribution. In the sandy valley bottoms and lower foothills of western Nevada eastward through central and northern Nevada into south-eastern Oregon, and central Utah (fig. 1). Flowering June to September.

Representative specimens. NEVADA without definite location: desert E of Walker Lake, *Bryan in 1859* (MO). Churchill Co.: Lahontan, *Headley* 8 (RENO); Burnt Cabin Canyon, *Beach* 1005 (UC); W of Eastgate, *Ripley & Barneby* 5940 (CAS, NY). Elko Co.: Sprucemont, *M. E. Jones in 1896* (A, UC); Cave Creek, Ruby Valley, *Mason* 4719 (UC); 6 mi NE of Elko, *Holmgren* 1103 (MO, OKL, UC, UTC). Esmeralda Co.: Goldfield, *Shockley in 1881* (RENO). Eureka Co.: 12 mi from Cortez, *Goodner & Henning* 963b (RENO); 2 mi N of Beowawe, *Holmgren* 1035 (OKL, UC, UTC). Humboldt Co.: W of Valmy, *Ripley & Barneby* 5598 (NY); 3 mi E of Quinn River Crossing, *N. Holmgren & Reveal* 1256 (ARIZ, BRY, CAS, DS, GH, KSC, MO, NY, RENO, RM, RSA, SMU, UC, US, UT, UTC). Lander Co.: Battle Mountain, *Kennedy* 3084 (DS); Battle Mountain, *A. E. Hitchcock* 638 (US); 10 mi E of Battle Mountain, *Eastwood & Howell* 157 (CAS); Kingston Canyon, *Goodner & Henning* 222 (RENO); 25 mi N of Austin, *Ripley & Barneby* 6195 (CAS, NY). Mineral Co.: Candelaria, *Shockley in 1881* (GH); Candelaria, *Shockley* 293 (DS, JEPS, GH, NY, UC). Nye Co.: Currant, *Bentley in 1916* (DS, MO, NY, RM, US); North Twin River, *Linsdale & Linsdale* 992 (CAS); 1.3 mi N of Belmont, *N. Holmgren & Reveal* 1542 (UTC). Pershing Co.: Unionville Valley, *Watson* 1034 (GH, NY, US). White Pine Co.: 30 mi W of Ely, *Delameter in 1947* (DS). OREGON. Harney Co.: White Horse Ranch, *Peck* 25637 (CAS, NY). UTAH. Beaver Co.: Milford, *M. E. Jones* 1793 (A, CAS, DS, MO, NY, OKL, RM, UC, UTC). Carbon Co.: E of Wellington, *Ripley & Barneby* 8640 (CAS, NY). Millard Co.: Tule Valley, *Maguire & Becraft* 2554 (UTC). Piute Co.: Marysville, *M. E. Jones* 5338ab (US). Sevier Co.: Sevier Valley, near Glenwood, *Ripley & Barneby* 4760 (CAS, NY).

ERIOGONUM NUTANS Torr. & Gray var. *glabratum* Reveal, var. nov. A var. *nutans* differt pedunculis et involucris glabris. Peduncles and involucre glabrous, ashy-gray; plant 1–3 dm high; Elko Co., Nevada. Type: 1 mi W of the Deeth turnoff, along the sandy roadside of U.S. 40, Elko Co., Nevada, June 20, and July 14, 1964, *N. H. Holmgren & J. L. Reveal* 1037 (UTC, isotypes ARIZ, BRY, CAS, DS, GH, KSC, MO, NY, RENO, RM, RSA, SMU, UC, US, UT, WIS).

Distribution. Known only from the dry valley floor from Wells to Halleck, Elko Co., Nevada (fig. 1). Flowering from June to September.

Representative specimens. NEVADA. Elko Co.: Halleck, *Heller* 9015 (NY, RENO, US); between Wells and Humboldt Wells, *Heller* 9194 (NY, RENO, US); Deeth, *Heller* 10561 (DS, NY, RENO, US); Wells, *M. E. Jones* 25220 (CAS, MO, UC); 3.6 mi W of Wells, *Stahmann* 8 (BRY); 3 mi W of Deeth, *Maguire et al* 5833 (UTC); 2 mi W of Halleck, *N. Holmgren & Reveal* 1468 (ARIZ, BRY, CAS, DS, GH, KSC, MO, NY, RENO, RM, RSA, SMU, UC, US, UT, UTC).



Most of the specimens cited above have been referred to *E. cernuum*, from which var. *glabratum* may be separated by its wide campanulate involucre, oblong non-undulated calyx-segments, and pubescent achene.

#### ACKNOWLEDGMENT

The author wishes to express his appreciation to Arthur H. Holmgren and W. S. Boyle for their many helpful suggestions. The assistance of Madame Antonia Gilles of the Herbiers de la Faculte des Sciences de Lyon in obtaining the Gandoger types is gratefully acknowledged. The collecting trip of N. H. Holmgren and this writer was largely supported by an NSF grant under the direction of Arthur Cronquist and Arthur H. Holmgren.

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#### NOTES AND NEWS

*Trees of the Panhandle, Golden Gate Park, San Francisco.* By ELIZABETH MCCLINTOCK and VIRGINIA MOORE. Miscellaneous Paper No. 1. vi + 58 pp. California Academy of Sciences, Golden Gate Park, San Francisco 94118. 1965. \$1.00. This pamphlet describes the 50 kinds of trees to be found in the eight block-long extension or Panhandle of Golden Gate Park. Photographs of most of the trees are included and there is a map of the Panhandle showing the location of each tree. Interesting bits of horticultural, botanical, and historical information are also presented. This booklet should be in the hands of every one interested in the trees of San Francisco.



## JENS C. CLAUSEN

We salute Dr. Jens C. Clausen, long-time member of the California Botanical Society. Jens, the son of a Danish farmer and house-builder, developed a strong interest in plants at an early age. An uncle introduced him to the flora of Denmark at the age of 9, and through extensive reading he absorbed much of the classic botanical literature while still a teen-ager. Jens' early interests also included geology and paleoecology, his curiosity in these fields having been aroused by the prominent glacial features of his native countryside.

His education was unorthodox as judged by current practices. He was taught at home until the age of 8, and by the time he was 13 had attended two upper grades of formal schooling. Later he studied at a private secondary school, but at 14 his education was interrupted by a stint at farming although his evenings were devoted to study. At 22 he entered the University of Copenhagen after passing a comprehensive entrance examination. While attending university he supported himself by teaching part-time at a private secondary school. His education was again interrupted during World War I by two years of military service in the Danish army. He received his Ph.D. degree from the University of Copenhagen in 1926 at the age of 34. During both his undergraduate and graduate years he was closely associated with Professor Øjvind Winge with whom he worked intensively on the cytogenetic exploration of various plant groups.

Dr. Clausen's thesis investigations on the cytogenetics of selected sections of the genus *Viola* attracted the attention of Dr. Harvey Monroe Hall of the Carnegie Institution of Washington. In 1931 Dr. Clausen became associated with Hall as a staff member of the Department of Plant Biology of the Carnegie Institution at Stanford.

Dr. Clausen's contributions as a member of a Carnegie team are too well known to require elaboration. He has received many honors, including election to the National Academy of Sciences, the Royal Swedish Academy of Sciences, the Royal Danish Academy of Sciences and Letters, and to honorary fellowship in the Botanical Society of Edinburgh. In 1949 he was awarded the honorary degree of Doctor of Agronomy at the Royal Agricultural College of Sweden, and in 1961 was knighted by King Frederik IX of Denmark to the Order of Dannebrog. Those who know him think of Jens Clausen as a keen, kindly scientist with unbounded enthusiasm and apparently limitless energy which he directs unstintingly to the enhancement of knowledge in the plant sciences.

## NOTES ON MARINE ALGAE OF WASHINGTON AND SOUTHERN BRITISH COLUMBIA

RICHARD E. NORRIS and JOHN WEST

Marine algae on the Pacific Coast of North America often show interesting distribution patterns because typically southern species are absent or rarely found in northern regions and northern species usually do not occur in southern waters. In recent years the number of species known only in southern or northern parts of the coast has become smaller, primarily through the records of Scagel (1957) and Dawson (1961). The following list of algae supplements the lists of Dawson and Scagel by recording species that have not previously been collected in Washington or southern British Columbia. In addition, further records for three rare genera, *Thuretellopsis*, *Porphyropsis*, and *Platysiphonia* are provided for this region. All specimens are in the herbarium of the University of Washington and are from the state of Washington unless otherwise indicated.

### CHLOROPHYTA

*Endophyton ramosum* Gardner was collected in thalli of *Iridaea* sp. in drift on a beach 2 miles W of the Sekiu R., Straits of Juan de Fuca, Clallam Co., Oct. 25, 1964 (Norris 5074). This endophyte has not been collected previously north of southern Oregon.

### PHAEOPHYTA

*Punctaria chartacea* Setchell & Gardner was collected by dredging in approximately 7 fathoms at Dot Rock, E of Decatur I., San Juan Co., June 18, 1964 (Norris 4618). It was also found intertidally at Whiffen Spit, Sooke, Vancouver I., British Columbia, July 10, 1964 (Norris 4747, West 133). This species was previously known only from Sitka, Alaska.

### RHODOPHYTA

*Porphyropsis coccinea* (J. Ag.) Rosenv. was observed by Kylin growing on hydrozoa in the vicinity of Friday Harbor. As far as we can determine, *Porphyropsis* has not been recorded on the North American west coast since that time. We found the same species on hydrozoa and *Rhodymenia* dredged from 5-7 fathoms at Hein Bank, SW of San Juan I., June 13, 1964 (Norris 4696).

*Thuretellopsis peggiana* Kylin. Previously known only from the type collection, cystocarpic specimens of this species were dredged in 5-7 fathoms at Salmon and Hein Banks, SW of San Juan I., on June 13, 1964 (Norris 4584, West 76).

*Gelidium sinicola* Gardner was collected on the reef at Mukkaw Bay, Clallam Co., on Oct. 24, 1964 (Norris 5087). This species has not been reported north of central Oregon before this time.



*Rhodophysema elegans* (J. Ag.) Dixon was found commonly in dredged material at Hein Bank, SW of San Juan I., June 13, 1964 (Norris 4695); Salmon Bank, SW of San Juan I., July 16, 1964 (Norris 4792); Partridge Bank, W of Whidbey I., July 27, 1964 (Norris 5010). This species has not been previously recorded north of central California.

*Rhodophysema georgii* Batt. was collected intertidally several times on leaves of *Phyllospadix* and *Zostera* at Whiffen Spit, Sooke, Vancouver I., British Columbia, July 12, 1964 (Norris 4752); N of False Bay, San Juan I., July 24, 1964 (Norris 4842); Cattle Pt., San Juan I., Aug. 8, 1964 (Norris 4970). The only previous record of this species from the northeastern Pacific is a collection from Cape Arago, Oregon, reported by Gardner (Doty, 1947). Doty was unable to find Gardner's specimens and the species has not been collected since that time. It is possible that the specimens reported here are a stage in the life history of *Smithora naiadum*, but the structure of the thalli seems to be identical with specimens from Great Britain.

*Dermatolithon pustulatum* f. *ascripticum* (Foslie) DeToni was collected at Mukkaw Bay, Clallam Co., Oct. 24, 1964 (Norris 5082). It was growing on *Botryoglossum ruprechtianum*. This coralline has been recorded previously no farther north than central Oregon.

*Rhodoglossum roseum* (Kylin) G. M. Smith was collected intertidally at Deadman Bay, San Juan I., June 25, 1964 (Norris 4680) and N of False Bay, San Juan I., July 24, 1964 (Norris 4828). This species formerly was known only from central California and Baja California.

*Gymnogongrus linearis* (Turner) J. Ag. was collected at Glacier Pt. (Point No. Pt.), S. Vancouver I., British Columbia (Norris 5136, West 150), on July 11, 1964. Previous to this time, this species was known only as far north as central Oregon.

*Besa papilliformis* Setchell was collected by dredging in 5-7 fathoms at Partridge Bank, W of Whidbey I., July 27, 1964 (Norris 5018). This species has been collected only twice before, in San Francisco and on the Monterey Peninsula.

*Callithamnion lejolisea* Farlow was collected on *Calliarthron regenerans* at American Camp Beach, San Juan I., July 9, 1964 (Norris 4858, West 120). Formerly this epiphyte was reported only as far north as central Oregon.

*Callithamnion endovagum* Setchell & Gardner was collected by dredging at Partridge Bank, W of Whidbey I., July 27, 1964 (Norris 4925), growing in thalli of *Opuntia*. Previously, this species was reported from Mexico and southern California.

*Spermothamnion snyderae* Farlow was collected by dredging in 5-7 fathoms at Salmon Bank, SW of San Juan I., June 13, 1964 (Norris 4586). It was also collected intertidally at Whiffen Spit, Sooke, Vancouver I., British Columbia, July 12, 1964 (Norris 4750), and at Mitchell Bay, San Juan I., July 7, 1964 (West 112). Collected specimens are sterile, but polysporangia are produced in culture.

*Ceramium eatonianum* (Farlow) DeToni was collected intertidally at Whiffen Spit, Sooke, Vancouver I., British Columbia, July 12, 1964 (*Norris 4751, West 134*) and at Meadow Point (Golden Gardens) Seattle, Nov. 21, 1964 (*Norris 5130, West 220*). Formerly this species was recorded as far north as central Oregon.

*Platysiphonia clevelandii* (Farlow) Papenfuss, previously known in this region only from Whidbey I., was collected by dredging in 5-7 fathoms at Salmon Bank, SW of San Juan I., June 13, 1964 (*Norris 4599*); by dredging at Smith I., Island Co., July 27, 1964 (*Norris 4890*); and by dredging at Hein Bank, SW of San Juan I., July 6, 1964 (*Norris 5014*). This species was isolated in unialgal culture from 4599.

*Membranoptera multiramosa* Gardner was collected by dredging in 5-7 fathoms at Salmon Bank, SW of San Juan I., July 16, 1964 (*Norris 4788*). This species formerly was recorded as far north as the central Oregon coast.

*Myriogramme hollenbergii* Kylin has been found in both dredged material and in intertidal collections: Whiffen Spit, Sooke, Vancouver I., British Columbia, July 12, 1964, (*Norris 4754, West 140*); dredged in 5-7 fathoms, W of Smith I., Island Co., July 27, 1964 (*Norris 4891*); on intertidal rocks, N of False Bay, San Juan I., July 24, 1964 (*Norris 4839*); dredged at Partridge Bank, W of Whidbey I., July 27, 1964 (*Norris 4914*). Unialgal cultures were isolated from 4914. This species has not been reported north of Monterey, California.

*Hymenena multiloba* (J. Ag.) Kylin was collected at Mukkaw Bay, Clallam Co., Oct. 24, 1964 (*Norris 4103*). Previously this species was reported only as far north as central Oregon.

*Cryptopleura lobulifera* (J. Ag.) Kylin was collected intertidally at Deadman Bay, San Juan I., June 25, 1964 (*Norris 4631*). This species has not been recorded farther north than central California.

*Polysiphonia brodiaei* (Dillwyn) Greville was collected on a wood float at Lloyd's Boat House, Duwamish Head, West Seattle, Jan. 14, 1965 (*West 225, 226, 228*). The previous known Pacific range of this well known Atlantic species was from Santa Monica to San Francisco Bay, California.

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## SOME NEW CHROMOSOME NUMBERS IN LINUM

C. MARVIN ROGERS and BETTY D. HARRIS

Chromosome complements in the North American species of *Linum* have been the subject of several papers (Dillman, 1933; Ray, 1944; Raven, 1959; Osborne and Lewis, 1962) and, among the species studied, there is evidence of considerable correlation between chromosome number and taxonomic groupings within the genus based on gross morphology. It is clear that a continuation of such studies may provide further substantiation and perhaps clarify the relationships among a number of species, the systematic position of which is poorly known. For this reason we have studied the following additional taxa: *L. bahamense*, *L. striatum*, *L. medium* var. *medium*, *L. australe*, *L. aristatum*, *L. alatum* and *L. pringlei*. We have also substantiated earlier counts of chromosome numbers in *L. lewisii* (13171, Catron Co., New Mexico) in which  $n = 9$ ; *L. sulcatum* (13191, Newaygo Co., Michigan) in which  $2n = 30$ ; and *L. medium* var. *texanum* (12517, Long Point, Ontario, and Harris 200, Wayne Co., Michigan) in which  $n = 18$ . Of the species for which new counts are presented, some are of particular interest in that they possess unusual chromosome numbers and may point to areas where further systematic and cytogenetic investigations would be profitable.

Young flower buds and root tips were fixed in Carnoy's fluid and stained with either aceto-carmin or aceto-orcin. Specimens of all of the collections examined are in the herbarium of Wayne State University. Collection numbers are those of C. M. Rogers except as otherwise indicated. This paper is contribution No. 130 from the Department of Biology, Wayne State University.

*Linum bahamense* Northrop var. *bahamense* (12138, Grand Bahama I.). The single collection so far examined has  $n = 34$ , unlike any other species in the genus thus far studied. This species, endemic to the Bahama Islands, is a member of a widespread North American complex which includes *L. arenicola* from Florida, as well as *L. schiedeanum*, *L. rupestre* and several other species which are predominantly Mexican. Of these only *L. schiedeanum* (under the name of *L. greggii*) and *L. arenicola* have been counted and each has  $n = 18$  (Osborne and Lewis, 1962). *Linum bahamense* may conceivably be an aneuploid variant of a tetraploid derivative of this series. The various populations of *L. bahamense*, distributed through several of the islands, have been, on the basis of morphological studies, treated as four species (Small, 1907) or as three varieties of one species (Rogers, 1963). A study of them now in progress may provide some data of interest concerning speciation in this island complex.

*Linum striatum* Walter (12166, Leon Co., Florida). The chromosome number is  $2n = 36$ , which is the same as that of *L. virginianum*, *L.*



*medium* var. *texanum* and *L. floridanum* var. *chrysocarpum* (Osborne and Lewis, 1962), all of which are members of a well defined eastern North American complex.

*Linum medium* (Planchon) Britton var. *medium* (12458, Bruce Peninsula, Ontario). This northernmost representative of the *L. medium-striatum-virginianum* group is thus far the only taxon to diverge from  $n = 18$ . While an exact count of the chromosomes has not been made, the variety appears to have a diploid number of approximately 72. It may have been derived as an allotetraploid from *L. medium* var. *texanum* and *L. virginianum*, both of which it resembles in a number of features. The morphological distinctions which exist between *L. medium* var. *medium* and var. *texanum* (Rogers, 1963), together with their different chromosome numbers, may indicate that the taxa would be better considered as two separate species.

*Linum australe* Heller var. *australe* (13169, Catron Co., New Mexico, and 13176, Coconino Co., Arizona); *L. aristatum* Engelm. (13177, Luna Co., New Mexico, and 13152, Culberson Co., Texas); and *L. alatum* (Small) Winkler (13131, Refugio Co., Texas). These three taxa, part of the *L. rigidum* complex, have, like *L. rigidum* (Dillman, 1933) been found to have  $n = 15$ .

*Linum pringlei* S. Watson (13181, 12 miles west of Durango, Mexico, and 13182, 18 miles west of Durango). On the basis of relatively little material seen, this species appears to be closely related to, but distinct from, *L. neomexicanum*. It may also be allied to *L. kingii* of Utah and such Mexican species as *L. mexicanum* and *L. hypericifolium*, but the relationship of these plants to each other and to other species in the genus is not clear. *Linum pringlei* has  $n = 26$ . This is the first count for the complex and the study of other species may help in clarifying the significance of the unusual chromosome number.

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## SCLEROLINON, A NEW GENUS IN THE LINACEAE

C. MARVIN ROGERS

*Linum digynum* is a diminutive yellow-flowered annual ranging from east central California north to Washington and Idaho. Since it was originally described, *L. digynum* has been regularly placed in *Linum* or, occasionally, along with the other North American yellow-flowered species of flax, in the segregate genus *Cathartolinum*. At first glance, however, the species appears to resemble equally closely several other western annuals which were first set apart in the genus *Linum* as the section *Hesperolinon* (Gray, 1865) and subsequently (Small, 1907) as the genus *Hesperolinon*. The resemblance of *L. digynum* to *Hesperolinon* was noted by Brewer and Watson (1876) and Trelease (1887; 1897) who placed it in the section *Hesperolinon*. The recent inclusion of the western annual species, exclusive of *L. digynum*, under the genus *Hesperolinon* (Sharsmith, 1961) pointed up the need for a reexamination of this species to determine more precisely to which genus it properly belonged.

The plant is similar to many species of *Linum* in its yellow, un-appendaged petals, attached near the base of the stamen tube, and in its capitate stigmas, while it resembles *Hesperolinon* in its annual habit, bicarpellate fruit (though this is not common in that genus) and three-angled seeds.

Further examination, however, shows that *L. digynum* possesses an impressive array of features which are not shared with either of the other genera and that, rather than being a possible link between the two genera, it appears to stand on quite firm ground as a separate genus. Several of these unique features concern the fruit and include its shape, the rugulose surface, the thick, hard walls which have accounted for the selection of *Sclerolinon* as the new generic name, the false septa which are quite complete and similar to the true septa, and the separation of the fruit into four indehiscent nutlets. In addition, the very short style, comparatively large capitate stigmas, the diminutive stamens with anthers sometimes containing as few as 8–12 pollen grains per anther sac are distinctive, as is the shape and lacerate margin of the sepals and upper floral bracts. The haploid number of chromosomes is eight (Raven, 1959) and though some Old World species of *Linum* (including *L. catharticum*, which may be a relatively recent introduction into north-eastern North America) have this number, it has not been found among other North American species of the family. Furthermore, the geographical range of *L. digynum* is distinct from the ranges of species of *Hesperolinon* and the yellow-flowered species of *Linum*.

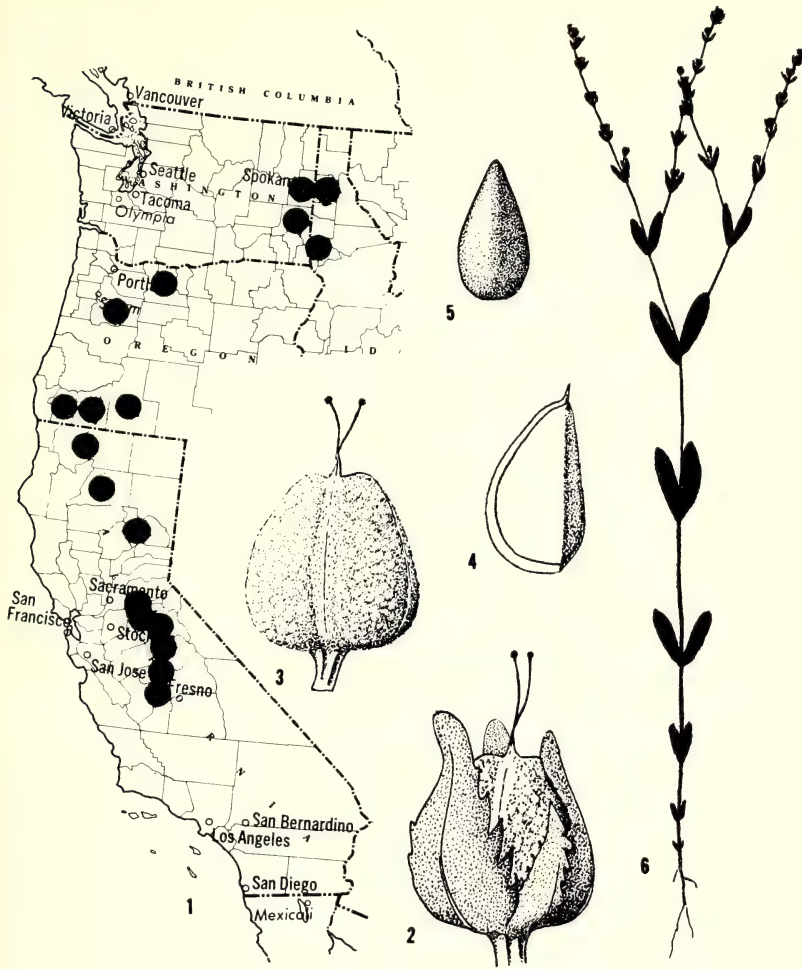
In that the primitive members of the genus *Linum* are thought to have five carpels with partially developed false septa and freely dehiscent

fruit, it is probable, on the basis of some of the characteristics mentioned above, plus such features as annual habit, the absence of staminodia and stipular glands, that *L. digynum* is one of the most highly specialized species of the family in North America. Its relationship to the other flaxes is not clear, but the features which it possesses in common with *Linum* and *Hesperolinon* may indicate that it has been derived from some ancestor along a line leading from the former to the latter, since *Hesperolinon*, too, appears to be more highly evolved than *Linum*. But if the species did originate in this fashion, it has since undergone considerable modification, and warrants its segregation into the monotypic genus *Sclerolinon*.

**Sclerolinon** Rogers, gen. nov. Annuum, glabrum; foliis oppositis oblongis; glandulis stipularibus nullis; sepalis oblongo-lanceolatis obtusis, margine lacerato-denticulatis glandulosisque; petalis flavis; dentibus inter stamina nullis; stylis 2 liberis; stigmatibus capitatis; capsula quadrilocellata. There is but one known species.

**Sclerolinon digynum** (Gray) Rogers, comb. nov. *Linum digynum* Gray, Proc. Am. Acad. 7:334. 1868. *Cathartolinum digynum* (Gray) Small, N. Am. Fl. 25:78. 1907.

Annual, glabrous herb (6-) 13-25 (-42) cm. tall; stems terete or somewhat striate above, simple or occasionally branched below, few-branched in the inflorescence; leaves opposite throughout or alternate above, 1-3 nerved, lanceolate to oblanceolate or elliptic, acute or obtuse, (6-)9-17 (-21) mm long, (1.6-)2.9-5.3(-8) mm wide, entire; stipular glands none; floral bracts narrowly lanceolate with few gland-tipped lacerations; sepals 5, unequal, the outer triangular-ovate to panduriform, obtuse, irregularly few-lacerate along the margin mostly below the middle, the teeth gland-tipped, outer sepals (1.7-)2.3-2.8(-4.5) mm long, the inner shorter, lance-ovate, with glandular teeth, but scarcely incised; petals 5 attached near base of stamen tube, obovate or obcordate, yellow, 3-4 mm long, without a well defined gland or appendages at the base; stamens 5, 1-2 mm long, glabrous, filaments hyaline, united at the somewhat broadened base; staminodia none; anthers elliptic, 0.1-0.3 mm long; fruit pale or occasionally lightly purple-tinged above, bicarpellate, 4-celled, 4-seeded, thick-walled, pyriform, broadly 4-angled, conspicuously mucronate at the otherwise truncate or retuse, clearly 4-angled summit, surface irregularly rugulose, (1.6-)1.7-1.8(-2) mm long, (1.4-)1.6-1.8(-1.9) mm in diameter, prominently jointed at the pedicel attachment point, ultimately falling intact, or very tardily dehiscent, at first along the true septa, then along the false septa, and falling as 4 indehiscent 1-seeded nutlets; false septa complete and similar to the true septa; styles separate or barely united at the base, 0.3-0.7 mm long; stigmas capitate, conspicuous; seeds filling locules, narrowly ovate, 3-angled, rather sharp pointed above, dark brown to nearly black, not glossy (figs. 2-6).



FIGS. 1-6. *Sclerolinon digynum*: 1, range; 2, fruit; enclosed in calyx,  $\times 15$ ; 3, fruit,  $\times 15$ ; 4, one segment of the fruit,  $\times 15$ ; 5, seed,  $\times 15$ ; 6, habit  $\times \frac{3}{4}$ .

In dry or more often moist meadows, at 3000-5000 feet, from east central California to southwestern Oregon and east central Washington and adjacent Idaho (fig. 1); flowering mainly from June to August.

Type: *Bolander 4900*, Yosemite Valley, Mariposa Co., California (US, isotype GH). The US specimen has been selected as the holotype, although Bolander's original collections are at GH. Both specimens were seen and annotated by Gray, but only the US sheet bears the data "Mariposa Trail" and what appears to be the original field note "valley, rare," both of which entered into the original description. In addition

the US specimen is the more ample one, while the GH sheet may be the source of some possible confusion in that it bears three additional collections.

Approximately 100 collections were examined, but only a single one from each county is cited.

CALIFORNIA. Amador: *Hansen 591* (US); Calaveras: *Eggleston 9713* (US); Fresno: *Raven 6125* (CAS); Madera: *Jenney*, June 15, 1914 (UC); Mariposa: *Bolander 4900* (GH, US); Plumas: *Hall 9382* (UC, US); Shasta: *Eastwood 710* (CAS, NY, POM, US); Siskiyou: *Brown 548½* (F. NY, PH, RM, US); Tuolumne: *Mason 2130* (CAS, DS, GH, MICH, NY, POM, UC, US). IDAHO. Kootenai: *Sandberg*, July 1888 (IA, KANU, NY); Nez Perce: *Sandberg et al. 311* (GH, NY, POM, US). OREGON. Jackson: *Copeland 3472* (CAS, GH, NY, POM, RM, UC, US); Josephine: *Peck 7931* (GH); Klamath: *Peck 9475* (DS, GH, NY, WTU); Linn: *Lloyd*, July 11, 1894 (CM, NY); Wasco: *Howell*, June 1881 (CM, DS, F, KSC, MICH, NY, OSC, PH). WASHINGTON. Spokane: *Suksdorf 8901* (CAS, DS, NY, RSA, UC, WTU); Whitman: *Piper 1803* (GH, WIS).

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#### NOTES AND NEWS

*Naming the Living World.* By THEODORE SAVORY. xiv + 128 pp. John Wiley & Sons Inc., New York. 1962. \$3.95. This book is divided into three parts: Principles of Nomenclature, Codes of Nomenclature, and Practice of Nomenclature. The first chapter, Follies and Foibles, of the last part is delightful reading with such sub-headings as: Light-hearted Names, Foolish Names, Worship of Priority, etc. In addition to providing a source of a good deal of information, the author has managed to get the idea across very nicely that "nomenclature is a servant of biology" and not an end in itself.



## NOTES ON MEXICAN GRASSES V. TWO GYPSOPHILOUS SPECIES OF MUHLENBERGIA

CHARLOTTE G. REEDER AND JOHN R. REEDER

This research was supported, in part, by Grants G-9070 and GB-2272 from the National Science Foundation. We are indebted to the curators of the following herbaria for making their facilities available: New York Botanical Garden (NY); U. S. National Herbarium (US); Escuela Nacional de Ciencias Biológicas, México (ENCB); Instituto de Investigación de Zonas Desérticas, San Luis Potosí, México (SLP). Chester F. Natunewicz, of the Classics Department at Yale, has kindly checked the Latin diagnosis.

In the spring of 1962, Alan A. Beetle, of the University of Wyoming, sent us a number of specimens of *Muhlenbergia* for determination. Among them was a single plant collected in Nuevo Leon, Mexico, by A. Cuevas, agronomist at the Instituto Tecnológico in Monterrey. Although this grass differed in several respects from any species with which we were familiar, and appeared to be a novelty, we were reluctant to describe it from only a single specimen.

The following autumn, in connection with attendance at the Segundo Congreso Mexicano de Botánica, we were able to visit the locality from which the Cuevas plant had come. Along the edges of a sizeable barranca about 3 miles southeast of Galeana, we found a few plants which were similar to the original collection. These were growing in gypsum soil, and associated with *Bouteloua chasei*, a marked gypsophile. The area is, in fact, the type locality of this latter species. Searching in a number of other gypsiferous areas in the states of Coahuila, Nuevo Leon, and San Luis Potosí, we encountered our plant in two additional localities. Always it appeared to be relatively rare, and usually was growing on the sides of sink-holes, which are a characteristic feature of these gypsum flats. For an excellent description of the physical characteristics of gypsum flats, see Johnston (1941).

In late October of the following year we were again in Mexico. Returning to the area near Galeana, we found our "new species" to be rather abundant, and a quite conspicuous element of the grass flora there. It was also apparent that it is by no means confined to sink-holes, but may be scattered about amongst the common and dominant elements of these areas: *Bouteloua chasei* Swallen and *Muhlenbergia villiflora* Hitchc.

In one of their papers dealing with the ecology and vegetation of the state of San Luis Potosí, Rzedowski & Rzedowski (1957) discussed the plants new to the State. Unreported for San Luis Potosí at that time was *Bouteloua chasei*, which the Rzedowskis had found in several gypsiferous areas. They indicated (p. 203): "... otra gramínea a veces dominante es una especie al parecer aún no descrita de *Muhlenbergia*." Even though

we had never found our "new species" abundant enough in any area to be considered dominant, we reasoned that perhaps it was the grass to which they had referred. In a conversation with Rzedowski, however, we learned that his supposedly unknown *Muhlenbergia* had been determined later at *M. purpusii* Mez. This little known species was originally collected by Purpus (#5011) in 1910, near the Minas de San Rafael in the state of San Luis Potosí. Hitchcock (1935) states that it is "known only from the type collection."

Through the courtesy of T. R. Soderstrom, of the U. S. National Herbarium, we were able to examine a type fragment of *M. purpusii*, along with two other collections (*McVaugh* et al. 18204 and *Rzedowski s. n.*). These latter two specimens were gathered in essentially the same locality, some 36 miles south of Matehuala in the state of San Luis Potosí. Later, while visiting the New York Botanical Garden Herbarium, we encountered a complete isotype of this species amongst the *Muhlenbergia* "indets."

There seems little doubt that *M. purpusii* is the species most closely related to the plant originally collected near Galeana by Ing. Cuevas. The two differ in a number of respects, however, and these appear to be sufficiently great to justify their segregation as quite distinct species.

***Muhlenbergia gypsophila* C. & J. Reeder, sp. nov.** Gramen perenne circiter 35 (raro ad 50) cm altum; culmis caespitosis teretibus erectis, sub nodis et sub inflorescentia dense pubescentibus, ceterum glabris; vaginis scabris vel apicem versus breviter pubescentibus, quam internodi longioribus; ligula 2–3 (1.5–6) mm longa, membranacea firma, apice truncata et breviter ciliata, marginibus puberulentibus et plusminusve decurrentibus; laminis falcatis 2–10 (raro ad 25) cm longis, involutis, rigidis, supra breviter pubescentibus, subtus plerumque glabris et levibus sed raro cum spiculis paucis praebitis; panícula exserta confertiflora. plerumque 7.5–15 cm longa, contracta; ramis arte appressis, ad basin paniculae plerumque 20 mm vel minus longis, in parte superiore brevioribus gradatim, rhachi pedicellisque brevibus plusminusve dense pubescentibus; spiculis stramineis vel interdum leviter purpuratis, glumis subaequalibus acutis 1.5–2 mm longis, obscure 1-nervalibus, puberulentibus praecipue apicem versus; lemmate 3-nervali pubescente 3.5–4 mm longa aristata, arista flexuosa 10–15 mm longa ex apice lemmatis bifida; palea lemmati amplitudine paene aequali, 2-nervali, inter nervos pubescente, ceterum glabra; antheris pallido-luteis 1.5–2 mm longis; stigmatibus penicilliformis purpureis; caryopside late fusiforma fusca circiter 2 mm longa; numero chromosomae  $2n = 20$ .

Type: MEXICO: Nuevo Leon, 3 miles east of junction of Linares-Galeana road with Hwy. 85, gypsum flat with widely scattered shrubs and tree yuccas, occasional in depression along roadside, 6400 ft, 30 Oct 1964, J. R. & C. G. Reeder 3963 (holotype, YU; isotype, US).

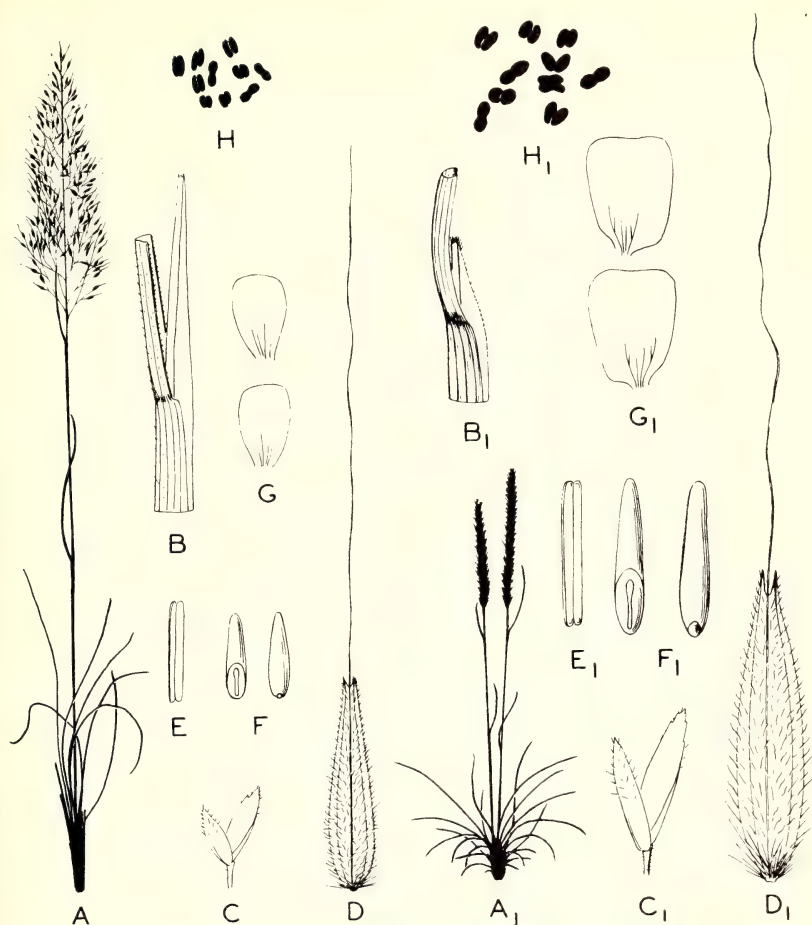


FIG. 1. Habit silhouettes and details of various structures. *Muhlenbergia purpusii* on the left; *M. gypsophila* on the right. A, A<sub>1</sub>, habit,  $\times$  ca.  $\frac{1}{6}$ ; B, B<sub>1</sub>, ligule,  $\times$  5; C, C<sub>1</sub>, glumes; D, D<sub>1</sub>, floret; E, E<sub>1</sub>, stamen; F, F<sub>1</sub>, caryopsis in two views (C-F<sub>1</sub>,  $\times$  10); G, G<sub>1</sub>, lodicules,  $\times$  50; H, H<sub>1</sub>, metaphase I of PMC division,  $\times$  900 ( $2n=20$ ). A-F from *Purpus* 5011; G & H from J. & C. Reeder 3669; A<sub>1</sub>-E<sub>1</sub> & G<sub>1</sub> from J. & C. Reeder 3963; F<sub>1</sub> from *Beetle* M-481; H<sub>1</sub> from J. & C. Reeder 3622.

#### Additional collections:

MEXICO: Coahuila, 35-36 mi S of Saltillo along road to Concepción del Oro, Zacatecas, 6200 ft, J. R. & C. G. Reeder 3622 (YU), 6000 ft, J. R. & C. G. Reeder 3987 (YU). Nuevo Leon: Galeana y cercanías, A. Cuevas 107 (YU), *Beetle* M-481 (US); 3-4 mi SE of Galeana, 5200 ft, J. R. & C. G. Reeder 3659 (YU); J. R. & C. G. Reeder 3965 (YU). San Luis Potosí: ca 12 mi NW of Matchuala on road to Cedral, 5500 ft, J. R. & C. G. Reeder 3668 (YU).

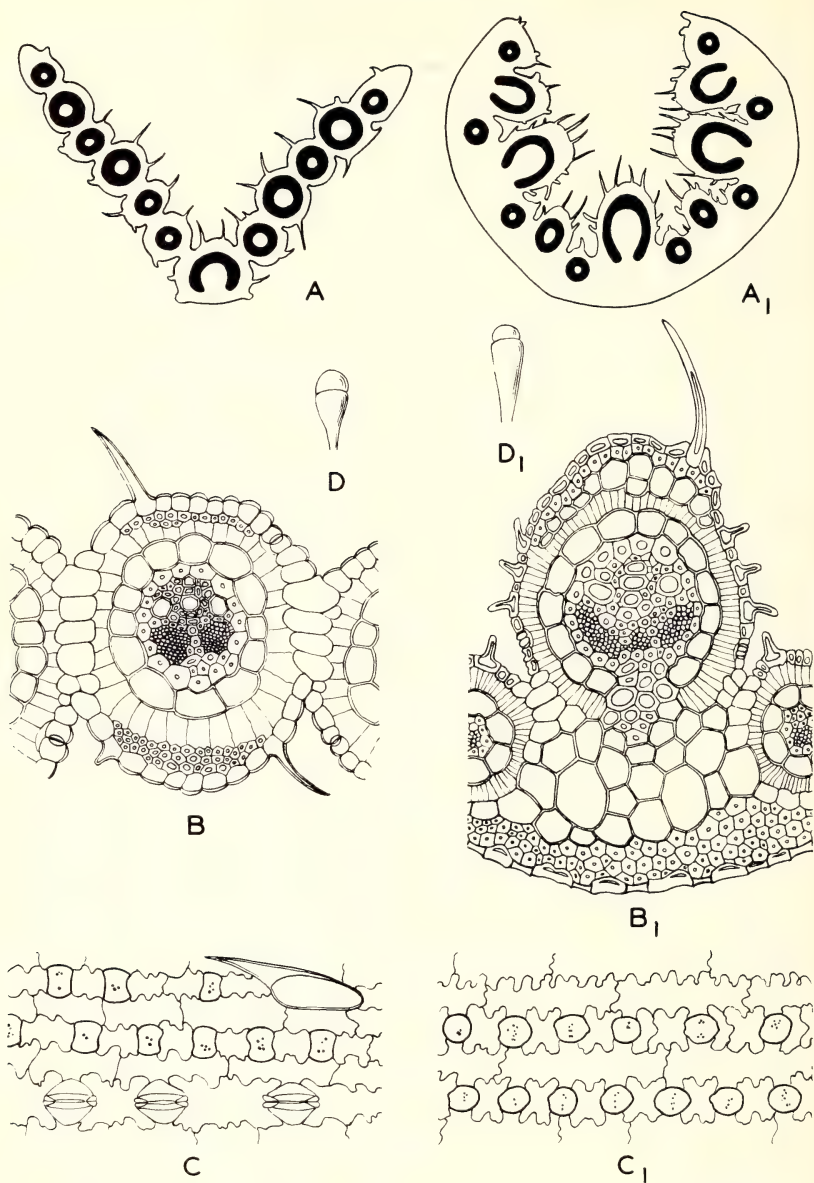


FIG. 2. Details of leaf anatomy and epidermis. *Muhlenbergia purpusii* (J. & C. Reeder 3669) on the left; *M. gypsophila* (J. & C. Reeder 3963) on the right. A, A<sub>1</sub>, diagram of transection of entire leaf blade,  $\times$  ca. 35 (the black areas represent parenchyma sheaths); B, B<sub>1</sub>, transection through region of a major vein, B,  $\times$  200; B<sub>1</sub>,  $\times$  150; C, C<sub>1</sub>, portion of epidermis from abaxial surface,  $\times$  225; D, D<sub>1</sub>, epidermal bicellular microhair,  $\times$  225. All drawings made from tracings of photomicrographs.



As indicated above, *M. gypsophila* appears to be related most closely to *M. purpusii*. These two species occupy similar habitats, and on one occasion we collected both in the same gypsum flat in San Luis Potosi. The most obvious difference between the two is that the new species is a somewhat smaller plant with a contracted spike-like panicle, whereas its ally is taller and the panicle is open. Both species have membranous ligules, but that of *M. gypsophila* is shorter and more firm. The leaf blades of the two appear somewhat alike but those of the new species are closely involute and essentially smooth on the abaxial surface, whereas in *M. purpusii* they are flat or folded and scabrous to hispidulous below. In spikelet morphology the two species are quite similar, but in *M. gypsophila* the glumes and florets are somewhat larger. This is true also in the case of lodicules, stamens, and caryopses (fig. 1).

Both species are diploid with a chromosome number of  $2n = 20$ , as determined from study of meiosis in pollen mother cells. It is noteworthy, however, that *M. gypsophila* has somewhat larger chromosomes (fig. 1, H & H<sub>1</sub>).

It has been noted already that the leaves of *M. gypsophila* are closely involute, whereas in *M. purpusii* they are flat or folded. More striking and important differences are revealed, however, when leaves of these two species are examined in transection. In those of *M. gypsophila* the lower epidermis is essentially smooth, whereas the upper surface bears numerous spines and papillae. The leaf has commonly 5 major bundles which are raised prominently above the remainder of the tissue. Two smaller bundles which are partially submerged occur one on either side of the midrib. Alternating with the units already mentioned are small bundles which are almost completely submerged in thick-walled parenchyma. Above the smooth lower epidermis is a layer of sclerenchyma 2 to 4 cells in thickness, and above this, thick-walled parenchyma which is in contact with the mesophyll. The major units show the familiar eragrostoid-chloridoid pattern, the bundle being surrounded by a double sheath, the inner of which consists of thick-walled sclerenchyma, and the outer of large parenchyma cells which contain chloroplasts. The parenchyma sheath is continuous in all except the 5 largest bundles. Outside this sheath, the cells of the mesophyll are arranged in a radial pattern. Bulliform cells in this leaf are rather poorly developed (fig. 2, A<sub>1</sub> & B<sub>1</sub>).

The contrast between the leaf described above and that of *M. purpusii* is striking. In the latter, spines and papillae are to be found in about equal numbers on both the upper and lower epidermis. It will be noted also that the units of the leaf differ only slightly in size, except for the larger midrib, and that they appear rather like the links of a chain. Each of these units is separated from its neighbors by a row of bulliform cells which extend from the upper to the lower epidermis. The bundles are of the typical eragrostoid-chloridoid type, as described above, but here the parenchyma sheath is continuous in all except the main vein. The radiat-

ing mesophyll extends to the bulliform cells on either side, and above and below is in contact with small patches of sclerenchyma which are just below the epidermis (fig. 2, A & B).

Not only the leaf transection, but also the epidermis is strikingly different in these two species. Both bear rather typical eragrostoid-chloroid bicellular microhairs, but these have a different shape and arrangement. In those of *M. purpusii*, which are shorter in overall length, the apical cell is proportionately somewhat larger. They are found in the intercostal regions of both the upper and lower epidermis, where the stomata are also located. The numerous siliceous cells, which are in the costal region, are saddle-shaped (fig. 2, C & D). On the lower epidermis of *M. gypsophila*, which is essentially smooth, there are no stomata nor microhairs. The most striking feature is, perhaps, its uniformity, there being little or no difference between the costal and intercostal areas. The entire epidermis consists of essentially three types of cells — long cells, short cells, and siliceous cells. These latter which are abundant and rounded in outline, quite unlike those of *M. purpusii*, occur in rows of alternating short and siliceous cells. These are separated from similar series by one or two rows of elongated cells. The long and short cells both have very wavy margins. The upper epidermis, as mentioned previously, bears numerous spines and papillae. Stomata are frequent in the intercostal regions, and bicellular microhairs occur in these areas as well. Neither stomata nor microhairs are to be found elsewhere on the leaves of this species (fig. 2, C<sub>1</sub> & D<sub>1</sub>).

To encounter such striking differences in the leaf anatomy and epidermis of presumably closely related species is certainly not to be expected. Perhaps the relationship here is, in fact, rather remote. The similarities in gross morphology may reflect parallelism or convergence rather than close genetic affinity.

*MUHLENBERGIA PURPUSII* Mez, in Repert. Sp. Nov. 17: 214. 1921.

Specimens examined: MEXICO. San Luis Potosí: Minas de San Rafael, Nov. 1910, *Purpus* 5011 (US, Type fragment; NY, isotype). Near the Minas de San Rafael in the Sierra de Guadalcázar, 1900–2100 m, *Sohns* 1515 (US, YU); 3 mi E of junction of Guadalcázar road and Hwy. 57, 5500 ft, *J. R. & C. G. Reeder* 4075 (YU); Near Km 549, 36 mi S of Matehuala, 1250 m, *McVaugh, Loveland & Phippen* 18204 (ENCB, US); Km 556, Carretera México-Piedras Negras, 1400 m, *Rzedowski s.n.* (US); San José del Refugio, carretera central, Km 550, *Medellin L.* 1130 (ENCB, SLP, YU); 12 mi NW of Matehuala on road to Cedral, 5500 ft, *J. R. & C. G. Reeder* 3669 (YU); 4 km al norte de Rioverde, sobre el camino a Pastora, 1000 m, *Rzedowski* 9574 (ENCB, SLP, YU).

Although *M. gypsophila* and *M. purpusii* occupy similar habitats, their ranges appear to be rather distinct. The new species has been collected in the states of Coahuila, Nuevo Leon, and northern San Luis Potosí. In the last locality it was found growing with *M. purpusii* and this is, indeed, the only area in which we have found these two species associated. All collections of *M. purpusii*, of which we are aware, have come from the



FIG. 3. Map showing the range of *Muhlenbergia gypsophila* (closed circles) and *M. purpusii* (open circles).

state of San Luis Potosí. The ranges of the two species, as far as we have been able to determine them, are shown on the map (fig. 3).

In his comprehensive thesis on the "Vegetación del Estado de San Luis Potosí," Rzedowski (1961) describes the gypsiferous areas in some detail. He refers to the vegetation of these habitats as "zacatal ralo," indicating that only about 30 per cent of the soil is occupied by plants, the dominant elements of which form circular colonies with bare centers [fairy-rings]. *Bouteloua chasei* and *M. purpusii* are given as the dominant grass species. In Fig. 26 of the publication cited above, which is a photograph of one of these habitats near Vallejo, the "fairy-rings" are clearly shown.

Rzedowski's description of the habitat applies well to most of the areas in which we have encountered both *M. purpusii* and *M. gypsophila*. Except for the region near Vallejo, however, in the areas in which we have observed *M. purpusii* it has not appeared to be a dominant element. For the most part, we have found it as scattered clumps amongst *Bouteloua chasei* and *M. villiflora* which in our experience are usually the dominants in these gypsum flats.

#### SUMMARY

*Muhlenbergia gypsophila*, a species apparently restricted to gypsum soils of north central Mexico, is described as new. It is compared with its presumed closest ally, *M. purpusii* Mez, a poorly known Mexican

endemic. Although both species are diploid ( $2n = 20$ ) and occupy similar habitats, detailed studies of the leaf anatomy and epidermis reveal striking differences between these two grasses. A range map showing the known collecting sites for both species is provided.

Yale University, New Haven, Connecticut

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# INFLUENCES OF FIRE AND SODIUM-CALCIUM BORATE ON CHAPARRAL VEGETATION

STEPHEN K. STOCKING

Fire is commonly recognized as an important factor in the determination of the composition of the extensive chaparral areas of California. Environmental conditions, physiognomy of the vegetation, and physiological responses of the individual components have led many authors to conclude that the chaparral is a firetype vegetation, the composition of which is perpetuated through the action of fire. Cooper (1922), Sampson (1944), Horton and Kraebel (1955), Patric and Hanes (1964) and Sweeney (1956) have made detailed ecological studies of chaparral areas of various parts of California. The literature on vegetation and fire has been reviewed by the above authors and by Ahlgren and Ahlgren (1960).

Seeds may germinate readily or require various conditions to break dormancy caused by embryo or seed coat conditions. Amen (1963) asserts that seed germination, germination mechanics, and the adaptive significance of the dormant state have not been adequately investigated. Quick (1935), Stone and Juhren (1951), Sweeney (1956), and Hadley (1961) have investigated the germination mechanics of some species which appear following chaparral fire. Sweeney (1956) found that both scarification and experimental burning of excelsior above planted seeds of "burn" species increased germination. Hadley (1961) increased germination of *Ceanothus megacarpus* both by scarification and by heating the seeds to 100° C for five minutes.

In recent years, chemicals such as sodium-calcium borate, bentonite clay, and diammonium phosphate have found increasing use as fire retardant chemicals. Experiments have shown that borate compounds inhibit germination and are toxic to mature plants when used in high concentrations (Brenchley, 1914; Crafts, 1956; Johansen, 1958). Field investigation of the effects of sodium-calcium borate on chaparral vegetation has not been reported.

The purpose of this investigation is mainly to record the nature of vegetation which appears following fire in a chamise chaparral area. Consideration is also given to germination responses of some of the herbaceous species which appeared on the burned area immediately following the fire and to the effect of sodium-calcium borate on growth in an affected area.

The study area is located in the southern Sierra Nevada foothills within Sequoia National Park. The study plots are in the lower Elk Creek drainage at an elevation of approximately 2100 feet. Soil is of the Vista



series (Storie and Weir, 1962), and ranges from two to five feet in depth. Weather and fire fighting data were taken from National Park Service records at the nearby Ash Mountain headquarters. The Tunnel Rock fire began June 25, 1960 and burned 4673 acres of chaparral and woodland on the south and east slopes of Ash Peaks. It was estimated that 25 to 30 500 gallon drops of sodium-calcium borate were made before the fire was brought under control.

Seventeen field plots, each four meters square, were located in the lower edge of the burned chaparral. Eleven of these plots are on the south-facing slopes which predominate in the burned area. Five plots are in the burned area, three on the margin of the borated and burned area, and three in the borated and burned area. The three control plots are in one of the few limited areas of unburned chaparral. All plots lie within a radius of 300 yards.

Ring counts were made of specimens of the woody perennial *Adenostoma fasciculatum* which had burned near the study plots. The number of annual rings in three complete sections varied from 45 to 51. The center of some sections was rotten or hollow, but 30 to 48 annual rings were visible even in the six incomplete specimens. Because aerial portions of this plant are killed by the heat of chaparral fire, it is assumed that there had not been a major fire in the immediate area for at least 50 years.

Principal observations and studies of the vegetation were made during the first growing season following the fire, the spring of 1961. Plant collections were made to determine the floristic composition of the area, and to find the frequency of occurrence of these plants on burned and adjacent unburned areas. The collections included 148 species, of which 118 were herbaceous, 25 annuals, 20 perennials, and seedlings of three woody perennials were found on the burned chaparral areas. Those species occurring on the study plots are listed in Table 1. More detailed information regarding distribution of vegetation in all areas may be found in Stocking (1962).

Marked differences in occurrence and abundance of certain species was evident when the burned area and the unburned control areas were compared. The chaparral cover of unburned south-facing slopes is predominately *Adenostoma fasciculatum*, *Ceanothus cuneatus*, *Arctostaphylos viscida*, *Fraxinus dipetala*, and *Quercus wislizenii* occur near margins of the dense chaparral and on the more mesic north-facing slopes. No seedlings of woody perennials were encountered either under the unburned brush or in openings in the brush. Only 12 herbaceous species were found in the control area. Failure of seedling establishment in these areas may be due to any of many factors including limited temperature range, root distribution, low light intensity, presence of inhibitors, and necessity of heat of fire for germination.

Seedlings of *Eriodictyon californicum* and *Ceanothus cuneatus* were occasionally encountered, particularly on the north-facing slopes (table



1). On burned chaparral areas, seedlings of chamise were abundant: 372 seedlings appeared on one 4 m study plot. Only three of these seedlings survived the hot dry summer. Survival of these seedlings varied on the different plots, but was low in all cases. Low survival of chamise is thought to be due to the shallow nature of the root system during the first year of growth.

Presence of herbaceous vegetation in open areas indicates that light intensity may play an important part in the establishment of some species in unburned chaparral areas. Species found most often in open areas in the brush of control plots are shown in Table 1. Of these species only *Lotus scoparius*, *Daucus pusillus*, and *Gastroidium ventricosum* were found on adjacent burned areas. Occurrence of these species in unburned brush areas indicates that conditions caused by fire are not requisite for their germination and growth. If invasion from unburned chaparral areas is to account for vegetation on the adjacent burned areas it would be expected that these species would predominate. Of the species which occurred on the burned area only the above mentioned species could have originated in neighboring unburned areas. The bulbous perennials, *Brodiaea lutea* var. *scabra*, and *Chloragalum pomeridianum* developed from underground bulbs on both burned and unburned areas. The other species of abundance on the burn were not present in the control area.

All of the scattered individuals of *Quercus wislizenii* and *Fraxinus dipetala* were in mesic locations, and all crown sprouted following the fire. Less than one-half of the burned chamise sprouted from their conspicuous basal burls. Most of these crown sprouts survived the first hot summer following the fire. No seedlings of any species were noted immediately adjacent to the bases of mature chamise. Lack of herbaceous vegetation near chamise may be due to the action of phytotoxic agent found in the leaves of the species by Naveh (1960). Herbaceous plants were present only where open areas existed in the otherwise dense cover of the control plots. The thinning out of the cover appeared to be due both to the advanced age of the stand and to the long period of low rainfall.

Observations were made of: 1, grassy areas surrounded by chaparral; 2, disturbed areas formed by an improved trail; and 3, disturbed areas formed by a road and utility right of way. The herbaceous flora of these burned areas differed from that of burned chaparral areas. With the exception of *D. pusillus*, and *Gastroidium ventricosum*, no species occurred on the burned chaparral area which also occurred on the disturbed areas. Presence of these species on the above mentioned areas may be due to many factors. It is possible that no mature plants, and therefore no seeds, existed on chaparral areas prior to the fire. It is also possible that the seeds of these species have low heat tolerance, and could survive fire only in open areas where the heat would not be so intense. The relation of heat generated by chaparral fire to seed survival and germination has been discussed by Sweeney (1956).

TABLE 1. SPECIES AND NUMBER OF INDIVIDUALS ON 4 BY 4 METER PLOTS. MARCH-MAY, 1961

SPECIES	Plots on South-Facing Slopes													Plots on North Facing Slope							
	Control Plots		Adjacent To Control					Borate Plots	Adjacent To Borate	Burned											
			1	2	3	4	5			1	2	3	4	5	1	2	3	4	5		
<i>Ranunculus<sup>1</sup></i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	5	2
<i>herbecarpus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Malacothamnus fremontii</i> (S)	—	—	—	5	1	16	21	120	—	—	—	1	1	—	—	—	2	1	—	6	2
<i>Dicentra</i>	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	33	18	3	5	53
<i>chrysantha</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	21
<i>Cerastium</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	4
<i>viscosum</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
<i>Montia</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	4
<i>perfoliata</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Linanthus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>ciliatus</i>	27	278	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Emmenanthe</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>penduliflora</i>	—	—	—	1	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Eriodictyon</i>	—	—	—	—	—	—	—	1	—	—	—	—	1	5	—	—	9	—	4	8	4
<i>californicum</i> (S)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
<i>Cryptantha</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
<i>micromeres</i>	—	—	—	—	53	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Crypantha</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>muricata</i>	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	—	—	2
<i>Scutellaria</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>tuberosa</i>	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	—	13	2



TABLE 1 (continued)

SPECIES	Plots on South-Facing Slopes																		Plots on North Facing Slope				
	Control Plots			Adjacent To Control			Borate Plots			Adjacent To Borate													
	1	2	3	1	2	3	4	5	Burned			Burned			Burned								
<i>Chloragalum pomeridianum</i>	2	2	10	—	—	—	3	3	58	287	415	79	49	103	12	7	4	3	11	4			
<i>Brodiaea lutea</i>	235	280	28	1560	241	470	908	174	—	—	—	—	—	—	24	340	—	153	34	90			
<i>var. scabra</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
<i>Brodiaea volubilis</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	113	34	—	—	115	—			
<i>Bromus madritensis</i>	17	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
<i>Festuca octoflora</i>	—	—	—	—	6	4	1	—	—	—	—	1	4	1	—	—	1	—	9	3			
<i>Festuca megalura</i>	80	42	478	11	—	5	2	2	—	—	—	3	—	6	1	8	—	4	5	—			
<i>Melica californica</i>	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1	—			
<i>Gastridium ventricosum</i>	—	25	—	10	2	47	6	26	—	—	—	7	3	37	3	5	—	10	2	2			

(S) indicates seedling of woody perennial. Plants which occurred only once were omitted. They were: *Dendromecon rigida*, *Clarkia unguiculata*, *Marah horridus*, *Stipa lepida*, and *Poa scabrella*.

<sup>1</sup> Nomenclature in this paper follows that of Munz (1959).



In addition to collections made in burned chaparral areas, many species were found in woodland and riparian areas burned in the same fire. No species were found in these areas which occurred in abundance on the chaparral area. This eliminated the likelihood of invasion from these areas during the first season following the fire.

*Dendromecon rigida* and *Emmenanthe penduliflora* were found in great abundance on localized areas of burned chaparral. These species were not found on unburned areas but have been located on other disturbed chaparral areas. They did not occur on the study plots. The most abundant herbaceous plant which appeared on burned chaparral areas was the perennial, *Astragalus congdonii*. *Malacothamnus fremontii* was locally abundant but only scattered in the area of the study plots. Both these plants are very rare in unburned chaparral areas. Only a few plants have been located by the author in disturbed areas of unburned chaparral in the southern Sierra Nevada.

Other seedlings found in abundance on burned chaparral areas, but rarely elsewhere, were *Crypantha micromeres*, *Trifolium ciliolatum*, *T. microcephalum*, *Lotus subpinnatus*, *L. micranthus*, and *Astragalus didymocarpus*. Distribution patterns of species restricted to the burn varied suggesting differences in abundance of these plants prior to the fire. *Emmenanthe penduliflora* was most common in rocky areas following the fire. This suggested that there were focal areas in which a few plants occurred in the interval between fires. Horton (1960) postulated similar origins of firetype plants in southern California.

*Ceanothus cuneatus* was nowhere abundant prior to fire, but seedlings appeared following fire on north-facing slopes (table 1). This finding concurs with those of Horton (1945), Hadley (1961), and Patric and Hanes (1964) who found that in areas unburned for over 50 years, *Ceanothus* spp. were replaced by species with a longer life span. Horton and Kraebel (1955) found that the seeds of *Ceanothus* spp. were stimulated to germinate through the action of fire. Although chamise seedlings were not found on the control areas they were abundant on the burned areas. Stone and Juhren (1953) found that chamise produced seeds with different germination responses at different times in their lives. They believed that an old stand of brush would contain a large number of viable seeds which would germinate in response to fire.

One possible explanation for the widespread abundance of *Astragalus congdonii*, *Trifolium ciliolatum*, and some other species on burned areas but not elsewhere is long term seed survival. It is possible that an abundance of seeds of these species had survived in the soil since a period of abundance following the last fire. These two species were found to have two types of seed, one which germinated readily and another more abundant type which required scarification for germination (table 2). The readily germinable seed would make possible scattered occurrence in the absence of fire. The other seed type would remain in the soil in the period between fires. Both species are legumes, a group which is

known to contain many species with long lived seeds (Quick, 1961). This condition could explain the widespread occurrence of these two plants following fire. *Emmenanthe penduliflora* and *Malacothamnus fremontii* were found to have seeds which would germinate only when scarified (table 2). It is postulated that these species occur in the absence of fire only where disturbances would break the seed coat of an occasional seed. This would explain their local abundance following fire. Amen (1963) states that the mechanisms of such dormancy are elusive, but that delayed germination represents a special adaptation which favors the continued propagation and survival of the species.

Burned north-facing slopes had a somewhat different cover of both annuals and perennials than did the plots on the drier south-facing slopes (table 1). In these areas vegetative activity was observed to begin earlier and reproductive activity to end later than on the south-facing slopes. Seedling survival of perennial species was also greater.

Observations made during the second spring following the fire indicated that the vegetational composition had changed. Annual species which were unique to the burned area during the first season had, for the most part, disappeared. Only a few individuals of *Emmenanthe penduliflora* were found at this time. The transient occurrence of such species suggests a direct relationship between fire and germination. Perennial species such as *Astragalus congdonii* and *Brodiaea lutea* var. *scabra* remained in abundance on the burned areas during the second season.

In the course of field investigations during the first growing season it was found that a section of the study area lacked the annual and perennial vegetation characteristics of other burned areas. It was learned that this area was one of 25 to 30 locations hit by aerial drops of the fire retardant chemical, sodium-calcium borate.

Complete lack of perennial and herbaceous seedlings in this area indicated that boron was present in highly toxic concentrations in the surface layers of the soil. At a depth of 0 to 7.6 cm, any toxic materials would be in contact with young absorbing roots. The one herbaceous perennial present, *Chlorogalum pomeridianum*, showed typical boron toxicity symptoms of leaf burn and marginal chlorosis. These symptoms in *Chlorogalum pomeridianum* suggested that boron was also present in the root zone of this plant, 7.6 to 30.5 cm beneath the surface. No conditions attributable to boron were exhibited by crown sprouts of chamise which has a deeper and more extensive root system than do the herbaceous species.

Vegetation of plots adjacent to the above mentioned area was more sparse than on neighboring unaffected areas. The species here were the same as on areas not affected by "borate." Sparsity of vegetation in this area suggested that boron was present in relatively low concentrations. The species present of the affected areas are shown in Table 1.

Colorimetric determination of boron in soil collected from the affected area was done according to the quantitative method of Hatcher and

TABLE 2. EFFECT OF MECHANICAL RUPTURING OF SEED COAT ON GERMINATION OF SOME BURN SPECIES INCLUDING TWO WITH SEED COAT DIMORPHISM

Species	Percentage germination <sup>1</sup>	
	Not Scarified	Scarified
<i>Malacothamnus fremontii</i>	0	30
<i>Emmenanthe penduliflora</i>	0	41
<i>Trifolium ciliolatum</i> (buff seed color)	65	—
<i>Trifolium ciliolatum</i> (mottled seed color)	0	82
<i>Astragalus congdonii</i> (buff seed color)	74	—
<i>Astragalus congdonii</i> (mottled seed color)	0	78

<sup>1</sup> Each treatment consisted of three replications using 25 seeds per dish. Germination was defined as emergence of the radicle by the end of 30 days.

Wilcox (1950). Analysis was made to determine the residual water soluble boron in the soil following aerial application. The manufacturer stated that concentrations of two to five ppm of boron in soil is toxic to most plants (U.S. Borax and Chemical Corp., 1957).

Boron is slowly removed from soil both by leaching and fixation. Crafts (1956) stated that a pattern of concentrated rainfall is much more effective in leaching soil sterilants of this type than is a comparable amount of intermittent rainfall. During the first winter following the application of "borate," rainfall was intermittent in occurrence and in small quantities. 5.66 cm of rain fell between the application and the collection of the first soil samples. Progressive leaching of the soil by low, intermittent rainfall is presumed to have reduced the boron concentration present immediately following application. At the end of the growing season, boron remaining in the top 7.6 cm of the soil in the affected area was reduced to 25 to 30 ppm. Fifteen ppm boron were found at depths of both 7.6 to 20.3 cm and 20.3 to 30.5 cm. All these concentrations are well above the minimum toxic concentrations. It is assumed that a somewhat higher boron concentration was present during the period of seed germination.

Analysis of soil collected in the same area during the second spring following the fire showed that 6.5 ppm of boron remained in the top 7.6 cm. This concentration remained after a total rainfall of 101 cm. It was again observed that no seedlings occurred in the area and that *Chlorogalum pomeridianum* continued to exhibit toxicity symptoms. Vegetation of the plots near the margin of the "borate" drop was much more abundant than during the first year. Vigorous chamise crown sprouts evidenced no toxicity in any areas.

These data indicate that concentrations of boron between 30 ppm and 6.5 ppm made seedling development impossible. Soil in this area remained sterile for twenty months after the aerial application of



"borate." At least 23.5 ppm of boron was removed by leaching or become unavailable by absorption during the second year following application. It is likely that 6.5 ppm of boron remained at the onset of the third winter (1962-1963). Rainfall during the winter of 1962-1963 was 75.11 cm.

Most seeds, both with or without seed coat dormancy, would germinate within the first two seasons following fire. Once these seeds began to germinate they would be exposed to the toxic concentrations of "borate." Not until the third growing season following fire did *Lactuca serriola*, a species with wind borne seeds, and a few grasses begin to appear at the margin of the area directly affected by the aerial drop. This would indicate that the rate of depletion continued during the third year, and that boron was reduced to below toxic levels.

Observations made during the springs of 1963 through 1965 showed that species appearing on the area which had been affected by "borate" were not the same as those which appeared on the surrounding unaffected chaparral area immediately following fire. Species found on the "borated" areas were predominately those of neighboring disturbed areas. Further study of such areas may lead to a better understanding of the comparative roles of invasion and seed survival in the establishment of plants on burned chaparral areas.

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## THE TAXONOMIC STATUS OF STEMMATELLA (COMPOSITAE-HELIANTHEAE)

B. L. TURNER

The genus *Stemmatella* was first proposed by Weddell (Bull. Soc. Bot. Fr. 12:82. 1865) in a list of plants collected in Bolivia by M. G. Mandon and identified by Schultz-Bipontinus. Specifically, the name *Stemmatella congesta* Wedd. preceded by the collector's No. 293, was listed without description or comment. As such *Stemmatella* was a *nomen nudum* until subsequently published by Hoffmann (1894) in his treatment of the Compositae. Bentham (1873), however, drew up a rather complete generic description, although he neglected to mention *S. congesta*, or any other species name, nor did he make reference to a specimen, but presumably he had access to one of the Mandon collections (see below).

I became interested in the taxonomy of *Stemmatella* while attempting to identify epappose forms of *Galinsoga parviflora* (Turner *et al.*, 1962; Turner and King, 1964), for such specimens, by Hoffmann's treatment would key to *Stemmatella* instead of *Galinsoga*; indeed, collections filed under the two generic names were almost identical, in spite of the fact that they were placed by both Bentham and Hoffmann in the subtribes Verbesininae and Galinsoginae respectively.

Bentham had a single sheet with 2 attached specimens of the *Mandon* 293 collection at his disposal (K). One of the specimens contains heads with epappose achenes; the other has heads with epappose ray achenes *but* the disk achenes possess a well-developed pappus. One must assume

that Bentham examined only the former in drawing up his otherwise excellent generic description.<sup>1</sup> Hoffmann, apparently relying on Bentham's treatment, also assumed that the disk achenes were epappose, for this is the character which he uses to separate *Stemmatella* from the subtribe Galinsoginae. In any case, I have examined in detail nine isotypes of *S. congesta* (K, 2; NY, 6; US, 1; the plants are all quite dwarf as if closely browsed or trodden on) and in each (except for one of the specimens at Kew) the ray achenes are epappose while the disk achenes support a well-developed pappus, very similar to that of *Galinsoga parviflora*.

Hoffmann, after his 1894 treatment of *Stemmatella* in which but a single species was acknowledged, must have recognized additional species, for in 1901 we find Hieronymus publishing a manuscript name of Hoffmann's, *Stemmatella urticifolia* (H.B.K.) O. Hoffm. ex Hieron. (Bot. Jahb. 28:601). In this same publication Hieronymus described two additional species, *S. sodiroi* and *S. lehmannii*. Both of the latter were recognized as closely related to *S. urticifolia*. Oddly enough, Hieronymus himself must have recognized the illogical separation of the two genera, for after his description of *S. sodiroi* he comments, "An igitur melius genus *Stemmatella* genere *Galinsoga* conjungendum sit?" He was, in fact, as indicated below, describing nothing but a form (with glabrate achenes) of *Galinsoga urticifolia* (H.B.K.) Benth.

Having now examined type material of all of the species-names proposed for *Stemmatella*, it is my opinion that the genus should be submerged in *Galinsoga*.<sup>2</sup> My nomenclatural and morphological observations follow:

STEMMATELLA CONGESTA Wedd. ex Hoffm., Naturl. Pflanzenfam. 4(5): 231. 1894. Bolivia, Prov. Larecaga "Viciniis sorata," Mandon 293, (w/o date), (isotypes, GH!, K!, NY!, US!).

The nature of the types on which this name is based is discussed above. *Stemmatella congesta* appears to be closest to *Galinsoga calva* Rusby (non *G. calva* Sch.-Bip., 1865; *nomen nudum*). The Mandon 293

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<sup>1</sup> Ironically, in the original version of the present paper, after my initial examination of the material at Kew, I implied that Bentham had been guilty of faulty observation. In fact, I had looked at *only* the specimen which Bentham had not examined—I am grateful to the reviewer of this paper for suggesting a second look.

<sup>2</sup> While re-examining specimens at Kew filed under the generic name *Stemmatella*, I came across an unpublished manuscript (inserted in one of the species-folders) entitled "Notes by P. G. Wilson, 1957." Mr. Wilson makes the following observations which substantiate my own, "*Stemmatella* Wedd. has been delimited in the Genera Plantarum by having the ray florets enclosed within an outer involucre bract and two palae, as well as having naked achenes. This description applies to *Wiborgia urticifolia* Kunth which has been transferred to *Stemmatella* by Hoffm. ex Hieronymus. However, the character of the ray florets being enclosed within three bracts is also held by *Galinsoga* which normally has achenes with a pappus. *W. urticifolia* matches *Galinsoga hispida* Benth. exactly, except for the pappus character (present in *G. hispida*) and they come from the same locality."

collections are a good match for isotypic material of *G. calva* (Bolivia, Talca Chugiaguillo, *A. Miguel Bang* 809, Apr. 1890) which was examined at Kew. The latter is from the same general area, has similar, congested heads, ray achenes without pappus and disc achenes with pappus, etc. A critical evaluation of the nomenclatural status of the numerous specific names proposed for *Galinsoga* must await a more thorough biological study of that genus, but in my opinion there can be no question but what the type species of *Stemmatella* is in fact a *Galinsoga*.

*GALINSOGA URTICIFOLIA* (H.B.K.) Benth., Oesterr. Vid. Middel. 102. 1852. *Wiborgia urticifolia* H.B.K., Nov. Gen. Sp. 4:201 (257) *t.* 389. 1820. "Crescit juxta villam Marchionis de Miraflores, inter Mulalo et Pansache, alt. 1700 hex. (Regno Quitensi.);" June. *Sabazia urticifolia* (H.B.K.) DC., Prod. 5:497. 1836. *Stemmatella urticifolia* (H.B.K.) O. Hoffm. ex Hieron., Bot. Jahrb. 28: 601 1901. *Stemmatella sodiroi* O. Hoffm. ex Hieron., Bot. Jahrb. 28: 601-602. 1901. Ecuador, Crescit in regione interandina, *Sodiro* 31/1, (fragment of holotype, US!; phototypes, GH!, NY!, US!). *Stemmatella urticifolia* var. *eglandulosa* Hieron., Bot. Jahrb. 36:487. 1905, as *Stematella*. Peru, near Cutervo, April 1879, *Jelski* 609. *Sabazia urticifolia* var. *venezuelensis* Steyer., Fieldiana Bot. 28: 672. 1953. Venezuela, Lara, "Pastured open slopes of mountain between Santo Domingo and Los Quebraditos," *J. A. Steyermark* 55379, Feb. 8, 1944, (holotype, F!).

*Galinsoga urticifolia* is, except for its epappose disk florets, very similar to *G. parviflora* (as noted by Wilson, cf. footnote 3, above). However, its natural distribution and ecology appears to differ from the latter in that it occupies more tropical, wetter areas at presumably somewhat higher elevations. *G. parviflora* is more widespread, occurring in both tropical and subtropical areas, usually in dryer, somewhat lower habitats. These two species unquestionably come in close contact in certain areas so that hybridization must be reckoned as a factor in their variation. Additional cyto-morphological observations can be found in Turner et al. (1962) and Turner & King (1964).

*Stemmatella urticifolia* var. *eglandulosa* and *Sabazia urticifolia* var. *venezuelensis* are apparently only forms of the species, the former lacking glandular trichomes on the stems and the latter possessing more densely pubescent achenes than is typical for the species. Both of these conditions in varying combinations are found in individuals from throughout the range of *Galinsoga urticifolia*.

*STEMMATELLA LEHMANII* Hieron., Bot. Jahrb. 28:602. 1902. Columbia, Vicinity of Popayan, 1600-2200 m, *Lehmann* 5667 (phototypes, NY!, TEX!, US!).

This species appears to belong to the genus *Sabazia*. It is apparently a perennial with thin rhizomes (*Core* 1015); the heads are relatively large on long peduncles which arise singly from the leaf axils; the ligules are quite well developed and, in proportion to their length, shortly 3-



lobed. To my knowledge, these characters are not found in *Galinsoga*. Except for the types, the only collection of this taxon which I have examined has been that of *Core 1015* (US), from a roadside between Valencia and San Sebastian, Colombia, 21 July, 1944: "Weed in thickets; disk flower yellow, ray flowers white above, pink beneath, rather showy."

Finally it should be noted that the epappose *Galinsoga mandonii* Sch.-Bip. (Linnaea 34:529. 1866), which is distinguished from the more widespread *G. urticifolia* by its smaller, congested (sessile) heads and deep purple involucre bracts, is sympatric with *G. urticifolia* in southern Bolivia and Peru. I have examined isotypic material of *G. mandonii* (Bolivia, Prov. Larecaja, *Mandon 76*, F, K) and the following collections, all from Peru: *Cook & Gilbert 210* (US); *Killip & Smith 21741* (F); *Macbride & Featherstone 573, 1582* (F). While closely related to *G. urticifolia*, it seems distinct; at least collections of a similar nature were not seen from the relatively well collected Colombia and Ecuador. However, a tendency toward intergradation with *G. mandonii* may be inferred from some of the collections of *G. urticifolia* from Peru (e.g., *Macbride & Featherstone 2105*, F).

As may be surmised, *Galinsoga* is in much need of experimental study, both in the garden and in the field. Several of its "species" have become widespread weeds in the wetter temperate regions of both hemispheres and because it grows well in such climates it ought to lend itself to experimental work in those areas. If the amplitude of morphological variation of the several tropical species of *Galinsoga* which I have examined is paralleled by a similar amplitude in physiological variation, then its success as an aggressive (or perhaps more aptly, "delightful") weed outside of its native habitat becomes explicable (cf. Baker's comments, 1962, on tropical weeds).

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# VOLATILE GROWTH INHIBITORS PRODUCED BY *EUCALYPTUS GLOBULUS*

HERBERT G. BAKER

The possibility that plants of some species gain advantage in natural competition by the excretion of substances (exocrines or ectocrines) inhibitory to the growth of their potential neighbors is under investigation in a number of laboratories. Among these investigations, the studies by Muller and his co-workers on volatile substances produced by aromatic shrubs have aroused considerable interest. Working particularly with *Salvia* and *Artemisia* they have shown that volatile terpenes from the leaves may inhibit root-growth of *Cucumis* seedlings placed in a closed container with them (Muller, Muller, and Haines, 1964). They have also demonstrated the presence of these terpenes in the air surrounding these shrubs in nature (Muller and Muller, 1964; Muller, 1965) and have postulated how they may enter the cells of victimized seedlings through solution in cuticular lipids (Muller, 1965).

The simplicity of the experimental set-up used by these workers in their demonstration of root-growth inhibition by volatile substances from shredded *Salvia* leaves suggested that this might form a suitable class exercise in an ecology course. Consequently, it was tried with the Evolutionary Plant Ecology course at the University of California, Berkeley, in the spring semester of 1964, with subsequent additional experiments which have been facilitated by National Science Foundation Research Grant No. G 21821. I am indebted to Charles Quibell who carried out the extra experiments, meantime making very valuable suggestions regarding technique.

Results obtained by the class were variable until the experimental design was fully standardized. The chambers and contents (fig. 1) were modeled after the setup described in Muller, Muller and Haines (1964). The seeds of *Cucumis sativus* L. were soaked in distilled water for 2 hours and then placed in position on the moist filter paper in the chambers. The glass lid to each chamber was fixed in place with petrolatum. The chambers were then kept together in the dark at 26.7°C (80°F) usually for 48 hours before measurements of root-growth were made. Only main roots were measured, laterals being ignored. The very few ungerminated seeds were also left out of account.

The availability of a small introduced population of *Salvia apiana* Jeps. on Grizzly Peak, Berkeley, enabled the results in Table 1A to be obtained. The differences between controls and test growths are all significant at the 1% level, confirming the findings of Muller et al.

However, it seemed likely that some other, more abundant local source of exocrines could be found. In the vicinity of Berkeley there are numerous plantations of *Eucalyptus globulus* Labill. under which very few

TABLE 1. VOLATILE GROWTH INHIBITORS PRODUCED BY EUCALYPTUS GLOBULUS

		Duration of Test (hours)	No. of Seedlings	Mean root- length (cms.)	Standard devia- tion	% of growth of control
A. <i>Salvia</i> leaves — <i>Cucumis</i> roots						
Control	(3 chambers)	48	142	2.20	0.56	
Salvia 1			42	1.62	0.54	74
Salvia 2			48	1.47	0.48	67
Salvia 3			42	1.48	0.48	67
Control	(2 chambers)	48	90	1.93	0.64	
Salvia	(2 chambers)		94	1.31	0.53	68
Control	(2 chambers)	60	83	2.86	1.04	
Salvia	(2 chambers)		70	2.09	0.60	73
Control	(4 chambers)	70	185	3.04	0.95	
Salvia	(3 chambers)		126	1.23	0.48	41
B. <i>Eucalyptus</i> leaves — <i>Cucumis</i> roots						
Control	(3 chambers)	48	142	2.20	0.56	
Eucalyptus 1			46	1.68	0.57	76
Eucalyptus 2			48	1.34	0.46	61
Eucalyptus 3			44	1.61	0.56	73
Control	(2 chambers)	48	90	1.93	0.64	
Eucalyptus	(2 chambers)		73	0.38	0.24	20
Control	(2 chambers)	60	83	2.86	1.04	
Eucalyptus	(2 chambers)		73	0.71	0.35	25
C. <i>Eucalyptus</i> leaves — <i>Eucalyptus</i> roots						
Control	(a)	24	50	0.67	0.27	
Juvenile Eucal.	(a)		51	0.56	0.17	83
Mature Eucal.	(a)		50	0.57	0.16	85
Control	(b)	24	48	0.91	0.11	
Juvenile Eucal.	(b)		50	0.83	0.25	91
Mature Eucal.	(b)		50	1.06	0.32	117
Control	(c)	24	10	1.35	0.32	
Juvenile Eucal.	(c)		10	1.33	0.30	99
Mature Eucal.	(c)		12	1.25	0.37	93
D. <i>Eucalyptus</i> leaves — <i>Eucalyptus</i> hypocotyls						
Control	(a)	24	50	0.33	0.07	
Juvenile Eucal.	(a)		51	0.25	0.05	76
Mature Eucal.	(a)		50	0.21	0.04	64
Control	(b)	24	48	0.43	0.15	
Juvenile Eucal.	(b)		50	0.28	0.06	66
Mature Eucal.	(b)		50	0.27	0.06	62
Control	(c)	24	10	0.48	0.14	
Juvenile Eucal.	(c)		10	0.25	0.04	53
Mature Eucal.	(c)		12	0.31	0.05	68

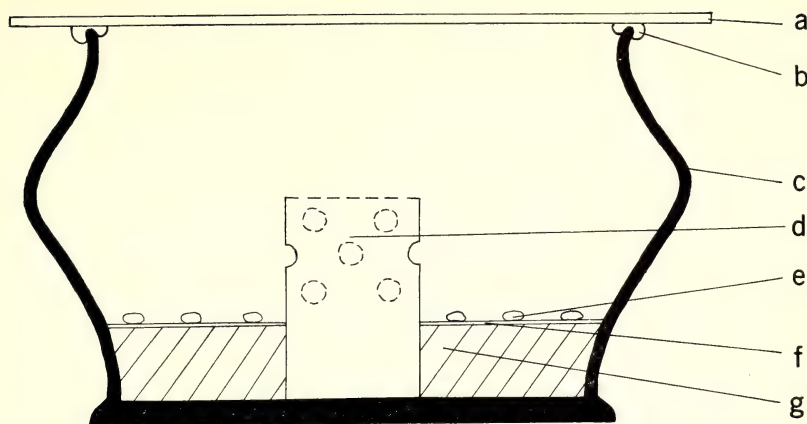


FIG. 1. Diagrammatic section through test chamber: a, glass lid; b, petrolatum seal; c, chamber; d, perforated container for test leaves; e, test seeds; f, filter paper; g, sponge, moistened with distilled water.

other plants grow. Although this forest tree has many natural associates in its native Australia, the contemporary California flora (a mixture of native species and mostly European introductions) appears generally to be unadapted to it as yet. The leaves of *E. globulus* are intensely aromatic, releasing a number of terpenes, including cineole (eucalyptole) (Baker and Smith, 1902). Cineole has been shown to be strongly inhibitory to root-growth (Muller and Muller, 1964) and to be one of the volatile toxins released by species of *Salvia* (Muller, 1965). Consequently, it seemed likely that terpenes from *E. globulus* might be responsible for the paucity of accompanying vegetation in the plantations.

Shredded *Eucalyptus* leaves proved to be just as efficacious as *Salvia* leaves in the inhibition of *Cucumis* seedling root-growth in class experiments in May, 1964 and in subsequent experiments in July 1964 (table 1B).

If volatile exocrines from *Eucalyptus* trees can be inhibitory to the root-growth of seedlings of other species, it is of interest to know their effects on the growth of their own seedlings. A modification of the experimental procedure was necessary in testing this, however, because *Eucalyptus* seed does not have the "simultaneous" germination pattern shown by *Cucumis*. It was necessary to germinate rather a large quantity of *Eucalyptus* seed after soaking for 48 hours in distilled water and then pick out seedlings with radicles of comparable length with which to begin the tests in the chambers. Table 1C shows the results obtained with shredded juvenile and adult leaves of *E. globulus* in the test chambers (the three sets of experiments being begun with germinated *Eucalyptus* seed having radicles of approximately (a) 1 mm, (b) 2 mm and (c) 3 mm, respectively).

Although exact comparisons between experiments carried out at separate times are not completely valid (and amounts of leaf were not weighed exactly), it seems that the leaves tested in July 1964 were more effective in inhibiting root-growth than those sampled earlier in the year, in May. This might reflect a difference in terpene production at these times.

For *E. globulus* root-growth, the test-results vary around 100% and none is significantly different at the 1% level from the controls, suggesting that the roots of this species are little affected by the volatile substances produced by the leaves of the same species. This might be advantageous in allowing more than one plant of the species to establish itself from seed in a newly-invaded area. On the other hand, there was a consistent effect ( $P \leq 0.01$ ) on the elongation of the hypocotyls of the *Eucalyptus* seedlings (table 1D). Several other experiments than those reported gave similar results with hypocotyl elongation. The ecological import of this finding has yet to be estimated.

The lack of effect of the volatile exocrines from *Eucalyptus* on the root-growth of its own seedlings recalls the apparent lack of sensitivity of the cells of *Colchicum* plants to the polyploidizing action of colchicine and the insensitivity to mutagenic allyl compounds shown by plants which produce them.

That plants will not always prove to be insensitive to the chemical products of their own species, however, is suggested by the observations of Went (1955) on creosote bushes (*Larrea divaricata* Cav.) which are often spaced remarkably evenly on the desert floors in California. Went attributes this to the susceptibility of *Larrea* seedlings to exocrines produced from the roots of existing creosote bushes, as a result of which seedlings only become established outside the radius of the circle of roots of existing shrubs.

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## THE CHROMOSOMES OF SCOLIOPUS (LILIACEAE)

MARION S. CAVE

Two species of *Scoliopus* have been described: 1, *S. bigelovii* Torr., occurring in the coast ranges of California from Santa Cruz Co. north to Humboldt Co. and 2, *S. hallii* Wats., from the west slope of the Cascades and Coast Mountains of Oregon.

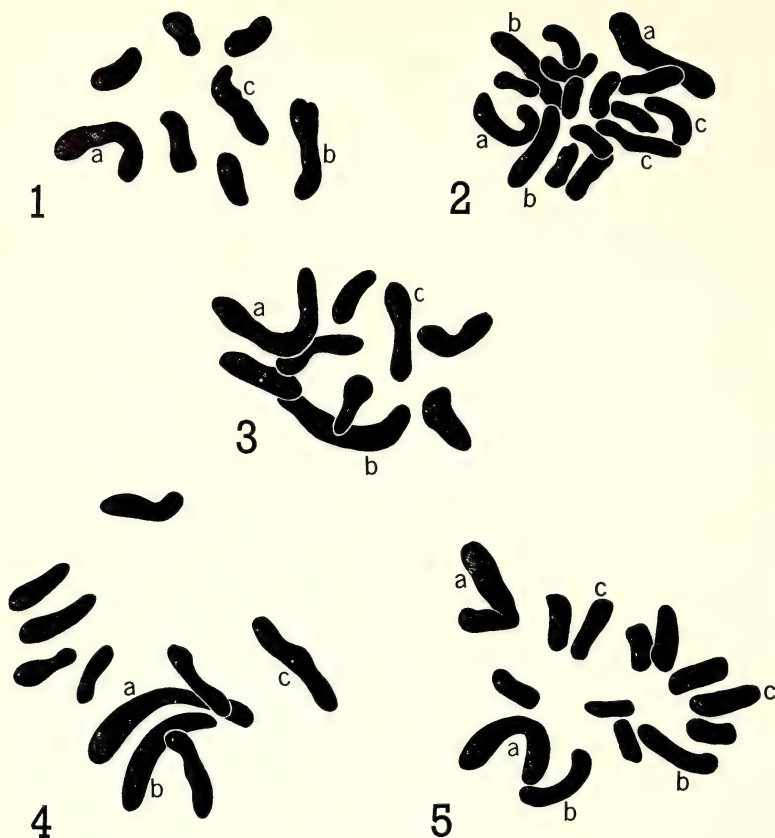
In 1932 Johansen reported 7 pairs of chromosomes in root tip material of *Scoliopus bigelovii*, originally obtained from the "native habitat" and "grown by the sand or water-culture method." He described the karyotype as: 1 long pair of chromosomes with medium constrictions, 1 long U-shaped pair, 1 medium-long straight pair, 1 medium-long curved pair, 2 short broad pairs, 1 short narrow pair.

Recently a number of collections of *S. bigelovii* (60.135, Sonoma Co., Cave 62150; 60.220, Humboldt Co., Cave 6530; 61.015, San Mateo Co., Cave 6514; 61.019, San Mateo Co., Cave 6506; 63.120, Sonoma Co., Cave 6515) made by Helen Mar Beard and Wayne Roderick, and now growing at the University of California Botanical Garden in Berkeley, have been examined for chromosome number, by means of the acetocarmine smear technique. By the time the tip of the first leaf is visible above the ground the youngest flower is already at the stage of mitosis in the microspore. Metaphase figures of this division (fig. 1) showed 8 chromosomes: 1 large (a), 2 medium-large (b and c), and 5 small. This discovery led the writer to examine some slides made in 1948 from material from Muir Woods, Marin Co., California. In all slides there were numerous examples of pollen grain metaphases with 8 chromosomes.

Pollen grains in all collections, save one, now growing at the Botanical Garden were of uniform size, with only a few scattered abortive cells, and the plants set good seed. Smears from ovules showed 16 mitotic chromosomes (fig. 2). That meiosis was normal is at least suggested. In the collections from Humboldt Co. there were also 16 mitotic chromosomes in the root tips, but the pollen grains were of all different sizes, and many were aborted. Two grains were found showing metaphases with 9 and 10 chromosomes respectively, including the 3 large ones, but varying numbers of small ones (figs. 3, 4). Pollen grains with deviating chromosome numbers may be the result of structural hybridity leading to asynapsis or desynapsis and consequent maldistribution of chromosomes at meiosis.

Root tips of the other species, *Scoliopus hallii*, received from Stanton Cook from Fall Creek, Lane Co., Oregon, had only 14 mitotic chromosomes (fig. 5). The 3 largest chromosome pairs resembled those in *S. bigelovii*, but there were only 4 small pairs.

The three largest chromosomes are probably homologous with Johansen's long U-shaped pair, medium-long straight pair, and medium-long



FIGS. 1-5 Chromosomes of *Scoliopus*: 1-4, *S. bigelovii*; 1, (6515) metaphase of division in microspore ( $n=8$ ); 2 (6506) metaphase from cell of ovule ( $2n=16$ ); 3, 4 (6530) metaphases of microspores showing extra chromosomes; 5, (65137) *S. hallii*, metaphase from root tip cell ( $2n=14$ ).  $\times 1660$ .

curved pair. His long pair with median constrictions, represented in his drawing by a thin line connecting the arms, is probably homologous with two of the short chromosome pairs found in the present collections of *S. bigelovii*. It would have been of interest to know the origin of his plants, because of the suggestion of structural hybridity in our collection of *S. bigelovii* from Humboldt Co. It is also possible that there are some populations in which translocation has given rise to a long chromosome from two short ones.

The taxonomic position of *Scoliopus* has recently been discussed by Berg (1959; 1962). He states that it should be removed from the Pari-deae of Krause (1930) and "placed in the Melanthoideae, probably as a tribe of its own near the Tricyrteae and the Uvularieae (and the Calochortae)". Berg accepted Johansen's count for *S. bigelovii* of  $2n = 14$ ,

but stated that the difference in basic chromosome number between this genus and other members of the Parideae cannot rightly be evaluated at present. It may be pointed out here that Satô's (1942) figure 54 of *Oakeisia sessilifolia* of the Uvularieae shows 3 fairly large pairs and 5 small pairs as do our examples of *Scoliopus bigelovii*. This similarity of karyotypes thus substantiates Berg's view of the close relationship of *Scoliopus* to the Uvularieae.

It will be of interest to see what is the number of chromosomes found in plants of both species of *Scoliopus* from other localities. The present study suggests that 8 is the normal haploid number for *S. bigelovii* and 7 for *S. hallii*.

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#### NOTES AND NEWS

THE OCCURRENCE OF A NEW ZEALAND PLANT, GERANIUM MICROPHYLLUM IN CALIFORNIA.—This small-flowered geranium native to New Zealand was first collected near Olema, Marin Co., in 1898 by Davy (4342, UC). Eastwood (Erythra 6:117. 1898) identified it as *G. sibiricum* L. and indicated that it was "abundant on the Abbott Ranch, at the entrance to Bear Valley." Howell (Marin Flora. 1949) annotated it as "perhaps a shade form of *G. pilosum* Forst. f.". A more recent collection was made in this same area (McHoul, May 3, 1965, UC) and has been identified as *G. microphyllum* Hook. f. Plants in this population numbered in the hundreds. *Geranium microphyllum* differs from *G. pilosum* and *G. retrorsum* L'Her. in having 1-flowered pedicels, white flowers with edges faintly tinged with pink, short, thickened roots, not tap roots, almost tuberous in character, and the caudex not branched. Two kinds of pubescence are present, long, white, slightly flattened, trichomes to 1 mm long and shorter hairs. The long trichomes are present on the edges and nerves of the subulate-tipped sepals and the shorter hairs are between the nerves. The upper sides of the leaves are dark green, sparsely covered with short trichomes. The under sides of the leaves are sparsely long and short pubescent and are grayish in color from a thick covering of minutely mealy granules—granulose rather than glandular. The pedicels below the flowers, the stems at nodes, and the petioles are thickly covered with long trichomes. A specimen was sent to Dr. G. Brownlie, University of Canterbury, New Zealand, who confirmed the identification. He indicated that although our specimens are larger in general than New Zealand plants, some in shady sites in scrub do approach the Olema specimens in size.—MARGARET S. BERGSENG, University of California Herbarium, Berkeley.

## TWO NEW SPECIES OF VERBESINA (COMPOSITAE) WITH TAXONOMIC NOTES ON OTHER SPECIES

JAMES R. COLEMAN

While working on a revision of the genus *Verbesina*, I encountered two previously undescribed species of section *Pterophyton* which are described herein. In addition, a confused taxonomic situation was discovered and is reported. This is part of a Ph.D. thesis submitted to Indiana University. This work was supported by fellowships from the National Science Foundation and Indiana University and I wish to express my gratitude to Charles B. Heiser who suggested this study and read the manuscript.

***Verbesina apiculata*** Coleman, sp. nov. Type: Ocurachui, Sierra Surotato, Sinaloa, Mexico, *Gentry 6263* (NY!).

Herb erecta perennis ca. 0.7 m alta; caulis anguste alatus; folia alterna sessilia lanceolate-oblonga vel linearia acuta vel acuminata usque ad 8 cm longa scabra; inflorescentia corymbosa capitulis 5–6 ca. 2 cm latis praedita; phyllaria ca. 2-seriata suboblonga ca. 3.5–4.0 mm longa; radii ca. 8 styliferi; receptacula convexa; paleae acutae vel apiculatae; achenia immatura obovata ca. 3 mm longa anguste alata pappi aristis 2 ca. 0.8 mm longis praedita.

Erect herbaceous perennial ca. 70 cm tall; stems to 3 mm in diameter, puberulent, winged to near the inflorescence (wings to 1.5 mm wide); leaves alternate, sessile, lance—oblong to linear, serrate to serrulate, acute to acuminate, to ca. 8 cm long, ca. 1.0–1.7 cm wide, scabrous above, hispid beneath, pinnately veined; peduncles to ca. 10 cm long; inflorescences corymbose, heads 5–6, ca. 2 cm wide; phyllaries ca. 2—seriate, oblong to subspatulate, ca. 3.5–4.0 mm long, obtuse or acute, black, some with tips recurved; ray florets ca. 8, styliferous, linear, ca. 1.7 cm long, hirtellous, awnless; disc florets ca. 7 mm long, corolla sparingly hirsute, ovary ca. 2.5 mm long, upwardly hirsute, awns ca. 0.8 mm long, style tips attenuate; receptacle convex; chaff ca. 5.5 mm long, hirsute, acute or apiculate, black apically; disc achenes (immature) obovate, ca. 3 mm long, 1.5 mm wide, the crown with a slightly thickened ridge, the wings ca. 0.2 mm wide, the margins ciliate, the awns 2 ca. 0.8 mm long, (fig. 1).

*Verbesina apiculata* is known only from the type material which the collector states as having been collected at about 6000–7000 feet in a pine forest area in a steep, moist, shady canyon with mixed dominants. The closest affinities of *V. apiculata* are with *V. rosei* from which it differs by its alternate, scabrous leaves and black phyllaries as well as by its styliferous ray florets. The leaves of *V. rosei* are opposite and strigillose. *Verbesina rosei* occurs about 350 miles SSE of the type locality of *V. apiculata* in the state of Nayrait.



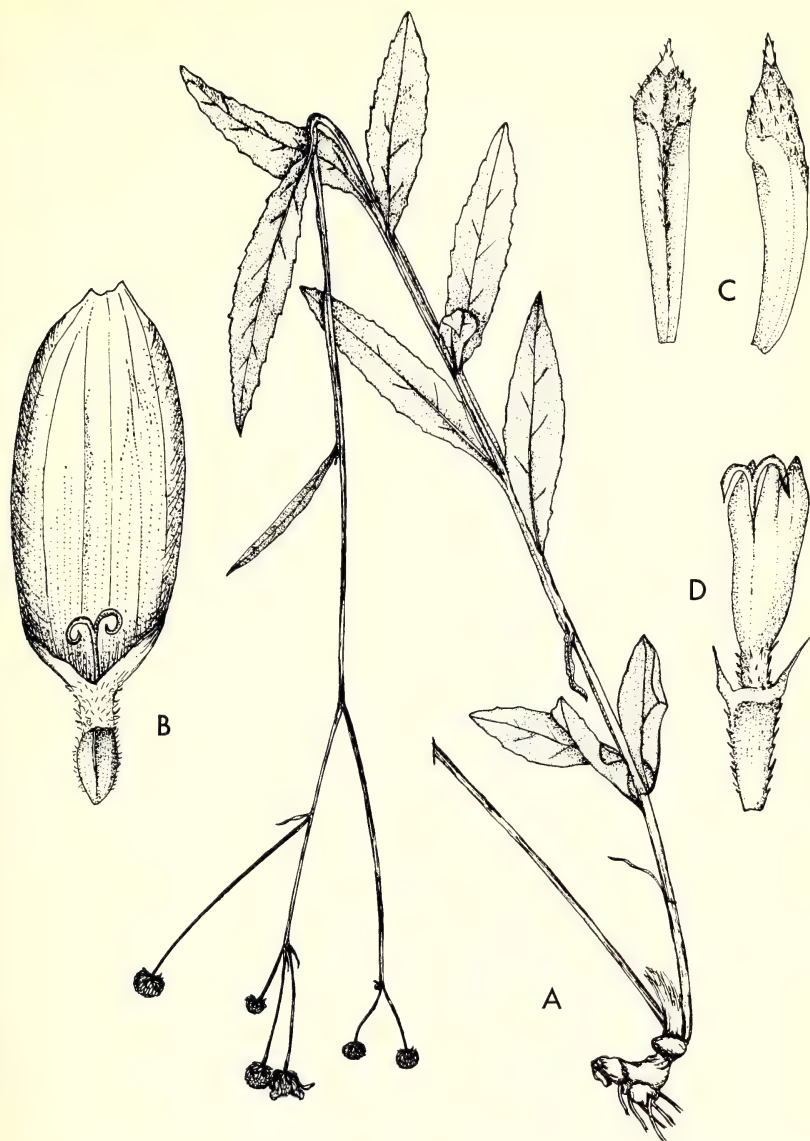


FIG. 1. *Verbesina apiculata*: A, habit sketch,  $\times$  ca.  $\frac{1}{3}$ ; B, ray floret,  $\times$  4.5; C, chaff,  $\times$  7; D, disc floret,  $\times$  7.5.

***Verbesina tequilana*** Coleman, sp. nov. Type: rocky hillsides, Tequila, Jalisco, Mexico, *Palmer 377* (NY!, isotype, NY!).

Herba erecta perennis; caulis alatus usque ad capitulum; folia plerumque opposita sessilia elliptica acuta ca. 5–8 cm longa penninervia scabra; capitulum ca. 4.5 cm latum; phyllaria 2–3—seriata oblonga ca.

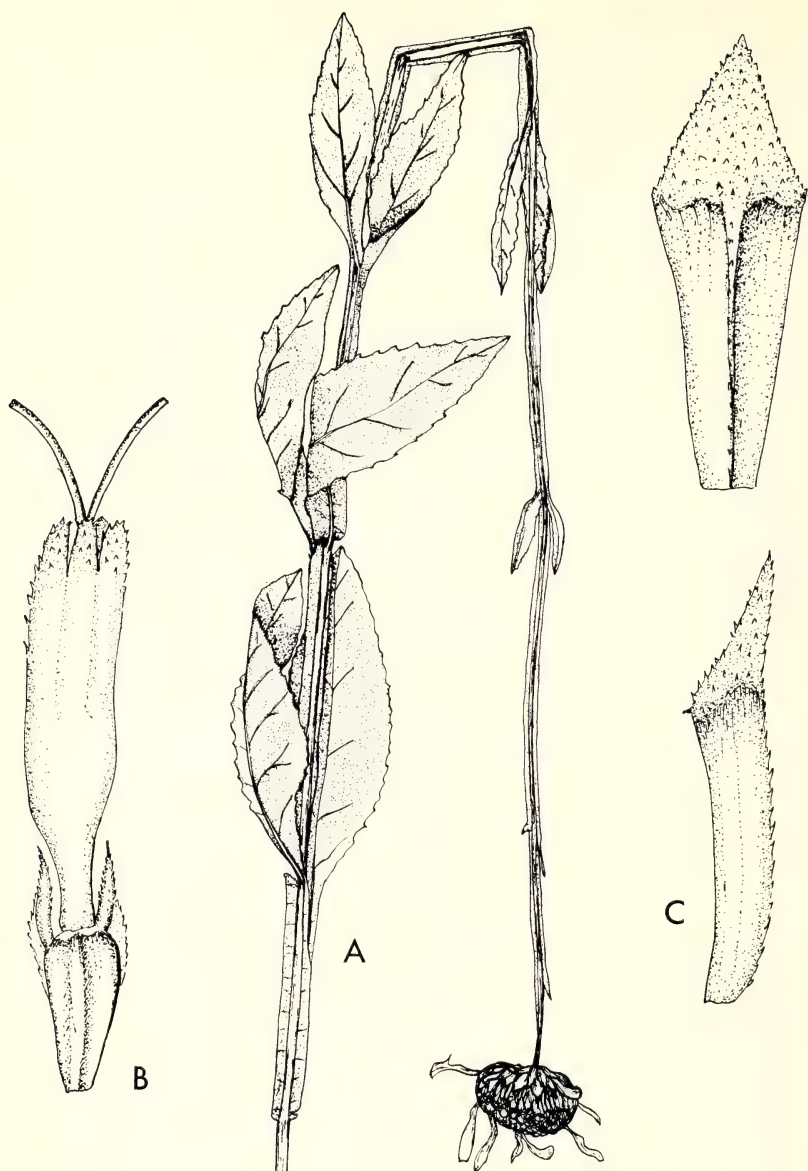


FIG. 2. *Verbesina tequilana*: A, habit sketch,  $\times$  ca.  $\frac{1}{3}$ ; B, disc floret,  $\times$  5.5; C, chaff,  $\times$  5.

5–8 mm longa marginibus revolutis praedita; radii ca. 10 styliiferi; ovaria ca. 4 mm longa pappi aristis 2 ca. 1.5 mm longis praedita.

Erect herbaceous perennial exceeding 1 m. tall; stems to 3 mm in diameter, winged to the heads (wings ca. 2.5 mm wide), sparingly

hirsute; leaves mostly opposite, becoming alternate above, sessile, elliptical, serrate, acute, ca. 5–8 cm long, ca. 2.5–4.0 cm wide, quite scabrous, pinnately veined; peduncles ca. 2 cm long; inflorescences 1–2—headed, heads ca. 4.5 cm wide, discs ca. 2 cm wide; phyllaries 2–3—seriate, oblong, obtuse, margins revolute, the outer series ca. 5–7 mm long, the inner series ca. 8 mm long; ray florets ca. 10–12, styliiferous, ca. 1.7 cm long, corolla sparingly hirsute, oblong, ovary ca. 2.5 mm long, awnless; disc florets ca 11 mm long, style tips attenuate, ovary ca. 4 mm long with marginal wings developing, the awns 2 ca. 1.5 mm long; chaff ca. 7–8 mm tall, acute (fig. 2).

*Verbesina tequilana* is known only from its type material which unfortunately lacks achenes. It is quite closely allied to *V. tetraptera* (Orteg.) Gray from which it is distinguishable by its sessile, elliptical, pinnately veined leaves and its fewer (ca. 10–12 vs. 15–25) and styliiferous ray florets. The generally rhomboid-hastate leaves of *V. tetraptera*, although varying greatly in shape, never approach being elliptical and are always distinctly petiolate and strongly triple nerved. The type locality of *V. tequilana* is approximately 200 miles NW of the known range of *V. tetraptera*.

The type of *V. tequilana* was referred by Robinson and Greenman (1899) to *V. scabra* Benth. which they placed in section *Alatipes*. They considered the specimen as being “surely distinct from *V. tetraptera*” and identified it with Bentham’s description and a drawing by Klatt. However an examination of an isotype and a photograph of the holotype permits no doubt of that species’ being identical with *V. tetraptera*. Blake (1930), commenting on this situation, said of Palmer 377, “it may represent a distinct species.” However he failed to describe it as such.

In their introduction to section *Pterophyton* Robinson and Greenman (1899) refer to *V. ovata*, but do not mention the name further except as a synonym of *V. pterocaula* (Moc. & Sess.) DC. to which they refer Delessert t. 597 and *Seaton* 340. A comparison of a photograph of Delessert’s drawing of *Mociño* and *Sessé* 30728 with *Seaton* 340 revealed that the two are certainly not of the same species. *Mociño* and *Sessé*’s specimen is depicted as having styliiferous ray florets, the ovaries bearing two well developed awns. Also, the leaves are linear-lanceolate with acuminate tips. *Seaton* 340 contrasts with this by having neutral ray florets, the ovaries of which are awnless, as well as by having acute or obtuse, oblong or elliptic-oblong leaves. *Seaton* 340 fits well enough the description and illustration of *Coreopsis ovata* Cav. which Gray later correctly transferred to *Verbesina*. Robinson and Greenman erred in applying the name *V. pterocaula* (Moc. & Sess.) DC. to *Seaton* 340 rather than *V. ovata* (Cav.) Gray and in citing the two specimens together.

*Verbesina pterocaula* is however a legitimate species which fits well into section *Verbesinaria*. A comparison of *Mociño* and *Sessé* 30728 with the type of *V. stenophylla* Greenman. (*Pringle* 6503), which Robinson

and Greenman placed in section *Verbesinaria*, revealed no significant differences. Since *V. pterocaula* has priority, it is necessary that *V. stenophylla* be reduced to a synonym of that species.

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### OBSERVATIONS ON WITCHES'-BROOM FORMATION, AUTOPARASITISM, AND NEW HOSTS IN PHORADENDRON

FRANK G. HAWKSWORTH AND DELBERT WIENS

During the course of field studies on *Arceuthobium* in the southwestern United States and Mexico, we also had the opportunity to make a number of collections of the related genus, *Phoradendron*. This report is a compilation of our observations on *Phoradendron*, including witches'-broom formation, autoparasitism, and some new hosts.

This research was supported, in part, by a cooperative agreement between the Rocky Mountain Forest and Range Experiment Station and the University of Colorado where the junior author was located during the conduct of the study. Herbaria abbreviations used here but not occurring in Index Herbariorum include: FPF—Forest Pathology Herbarium, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, and INIF—Instituto Nacional de Investigaciones Forestales, Mexico, D.F.

#### WITCHES'-BROOMS

Witches'-broom formation is a common symptom of conifers infected by *Arceuthobium*, but has not been reported previously to be associated with parasitism by *Phoradendron*. The only other reported instance of witches'-brooms caused by a member of the Loranthaceae is in Chile where brooms are induced by *Phrygilanthus tetrandrus* Eichler on *Populus* (Reiche, 1907; Kuijt, 1964). This report is verified (fig. 1) from collections made in Santiago, Chile (*Wiens* 3833 UT). Brooms in *Populus* consisted of masses of vertical branches that rose 5 to 10 ft. No broom formation was observed on native hosts attacked by this mistletoe.





FIG. 1. Witches'-broom on *Populus* induced by *Phrygilanthus tetrandrus*, Santiago, Chile.

In an area two miles south of La Cuesta along Highway 45, Durango, Mexico, we found *P. tomentosum* (DC.) Engelm. ex Gray ssp. *tomentosum* on several ocotillo plants, *Fouquieria fasciculata* (Roem. & Schult.) Nash (Wiens 3294, COLO; Hawksworth 324, FPF). The mistletoe was common nearby on *Forestiera*, and within a few miles on *Prosopis* and *Celtis*. The mistletoe plants on ocotillo were small (2 to 3 inches high), pale yellow, and generally of low vigor compared with those on the other hosts. Symptoms of infection included markedly swollen branches and formation of witches'-brooms (fig. 2).

During a recent trip to southeastern Utah, R. S. Peterson (pers. comm.) noted several massive witches'-brooms in Utah juniper, *Juniperus osteosperma* (Torr.) Little. His examinations showed that they were not of the type caused by rust fungi but, surprisingly, were associated with *P. juniperinum* Engelm. (fig. 3). The foliage in the broomed part of the tree was denser and darker green than in the non-broomed parts of the tree. Plants of *P. juniperinum* were distributed systemically throughout the brooms (Peterson 65-80, FPF) in a manner somewhat similar to parasitism of pines by certain dwarf-mistletoes, *Arceuthobium*

(Hawksworth, 1961; Kuijt, 1960). Non-systemic infections of *P. juniperinum* occurred both within the broomed and non-broomed parts of the tree. This is in contrast to *Arceuthobium* where non-systemic infections rarely occur on systemic brooms. Whether *P. juniperinum* actually stimulated development of latent or adventitious buds was not determined. The broom portions where the parasite developed systemically, however, had a dense, intricately branched live twig system. The non-broomed parts, conversely, possessed a sparsely branched, open branch system. Peterson has also observed similar brooms associated with *P. juniperinum* on *J. oteosperma* and *J. scopulorum* Sarg. at Bryce Canyon, Utah.

#### INTRA- AND INTER-SPECIFIC PARASITISM

Autoparasitism, i.e., the occurrence of one mistletoe on a different individual of the same species, has been reported for *P. serotinum* (Raf.) Johnston in Florida (Curtiss, 1878) and also for several tropical American mistletoes (Kuijt, 1964; Wellman, 1964). We have observed autoparasitism in *P. californicum* Nutt. near Tucson, Arizona, on the Mount Lemmon highway (Hawksworth & Lightle 174, FPF). We have also noticed autoparasitism in *P. tomentosum* ssp. *tomentosum* on Highway 40 about 50 miles east of Torreón, Chihuahua, Mexico (Wiens 2616, RSA) and in *P. villosum* (Nutt.) Nutt. ssp. *villosum* on Highway 30 3 miles south of Running Springs in the San Bernardino Mountains, California (Hawksworth 737, FPF).

The occurrence of mistletoes on other species and genera of mistletoe is common in the tropics (Kuijt, 1964; Wellman, 1964), but not in more temperate regions. The only previous instance that we are aware of in the United States is Brown's (1918) report of *P. californicum* on *P. tomentosum* (DC.) Engelm. ex Gray ssp. *macrophyllum* (Engelm.) Wiens in Arizona. In an area 3 miles east of the Mimbres River on Highway 180 in Grant Co., New Mexico, *P. juniperinum* was collected on *Juniperus deppeana* Steud. A closer examination of the collection (Hawksworth & Lightle 124a, FPF) revealed that an individual of the *P. juniperinum* was, in turn, parasitized by *P. villosum* ssp. *coryae* (Trel.) Wiens. The latter plant was young and had shoots only about one inch high. Typical individuals of *P. villosum* ssp. *coryae* were common in the vicinity on various oaks.

#### NEW AND UNUSUAL HOST-PARASITE COMBINATIONS

*Phoradendron californicum* Nutt. This mistletoe is a characteristic plant of the deserts of the southwestern United States and northwestern Mexico. Its hosts are principally leguminous shrubs (Wiens, 1964).

Harris et al. (1930) reported that the possible explanation for the "exceedingly rare" occurrence of *P. californicum* on creosote bush, *Larrea divaricata* (DC.) Coville, was that this shrub has a much higher osmotic concentration than the usual hosts for this mistletoe. The only case of parasitism of this shrub by *P. californicum* that they found was



FIG. 2. Witches'-broom on *Fouquieria fasciculata* caused by *Phoradendron tomentosum* subsp. *tomentosum*. Note hypertrophy and change in tropic response of branches on the broom. La Cuesta, Durango, Mexico.

at Sacaton, Arizona, near a pumping station where the soil moisture was abnormally high.

Our observations, and the listing of *Larrea divaricata* as an "occasional" host by Munz (1959), indicate that parasitism of this shrub is not as rare as the earlier reports suggested. We have found this host-parasite combination north of Amboy, San Bernardino Co., California, (Wiens 967, RSA) and in several localities in Arizona: Pinal Co., 10 miles north of Oracle Junction (Hawksworth 706, FPF) and near Apache Junction (Gill in 1965, FPF); Gila Co., 24 miles northwest of Globe (Lightle & Lampi 65-12, FPF) and Mohave Co., Black Range (Hawksworth & Peterson 723, FPF).

Similarly, L. S. Gill (pers. comm.) informs us that *P. californicum* is common on creosote bush in an area 11 to 15 miles south of San Felipe on the road to Puertecitos, Baja California, Mexico. He noted that wherever legumes were heavily infected, the associated creosote bushes were similarly infected (Gill, 1965, FPF). Creosote bush was not infected where it grew in pure stands or in association with legumes that were not attacked by the mistletoe.

*Phoradendron bolleanum* (Seem.) Eichler ssp. *bolleanum*. This mistletoe of northern Mexico exhibits "double specificity" that is unusual among phanerogamic parasites. Its principal hosts include a gymnosperm (*Juniperus*) and an angiosperm (*Arbutus*). We know of no other in-



stance where a mistletoe is essentially restricted to two such diverse genera. The occurrence of a Mexican mistletoe on *Arbutus* has been known for decades. Trelease (1916) questioned whether the same mistletoe occurred on such unrelated genera; however, Fosberg (1941) and Wiens (1964) stated that they were morphologically the same taxon. Our more recent observations in the Sierra Madre Occidental of Chihuahua and Durango confirm this. Usually *Arbutus* and *Juniperus* are infested with about equal frequency, although an occasional individual of *Arctostaphylos* is also attacked. Its occurrence on *Arctostaphylos* is perhaps not unexpected because of the close relationship of this genus to *Arbutus*. Cross inoculation experiments might be desirable to preclude the possibility that the populations on *Arbutus* and *Juniperus* are not morphologically indistinguishable physiological races.

*Phoradendron bolleanum* ssp. *pauciflorum* (Torr.) Wiens. This mistletoe is a common parasite of *Abies concolor* (Gord. & Glend.) Lindl. in Baja California, California, and in the Santa Catalina Mountains in Arizona (Wiens, 1964). In the Sierra San Pedro Mártir of Baja California we found it rarely parasitizing *Cupressus arizonica* var. *montana* (Wiggins) Little (*Hawksworth & Scharpf* 763, DS, FPF, INIF, UT). The mistletoe was present in the vicinity on *Abies*.

*Phoradendron bolleanum* ssp. *densum* (Torr.) Wiens, a mistletoe found on *Cupressus* and *Juniperus* in Arizona and California, also occurs on the lower parts of the Sierra San Pedro Mártir on *Juniperus californica* Carr. However, our observations indicate that here *P. bolleanum* ssp. *densum* is not sympatric with *Cupressus*, which occurs about 2,000 to 3,000 feet higher.

*Phoradendron villosum* (Nutt.) Nutt. ssp. *villosum*. This taxon is the common oak-infesting mistletoe of the Pacific Coast States, ranging from northern Baja California to central Oregon west of the Cascades (Wiens, 1964). In addition to oaks, it sometimes parasitizes *Umbellularia*, *Aesculus*, *Arctostaphylos*, *Castanopsis*, *Fraxinus*, *Adenostoma*, (McMinn, 1951) and *Rhus* when these grow in association with infected oaks.

In Baja California, this parasite occurs on two host species apparently not previously recorded in the literature, although both genera are infected in California. Along the road east of Rancho San Jose, on the approach to the Sierra San Pedro Mártir, we collected this mistletoe on *Adenostoma sparsifolium* Torr. (*Hawksworth & Scharpf* 754, DS, FPF, INIF) and on *Rhus ovata* Wats. (*Hawksworth & Scharpf* 757, DS, FPF, INIF). This mistletoe also occurs on the latter host 72 miles south of Ensenada on Mexico Route 1 (*Lightle & Gill* 64-36, DS, FPF, INIF). Several infected shrubs of both species were observed, sometimes at considerable distances from the closest infected oaks.

*Phoradendron villosum* ssp. *coryae* (Trel.) Wiens. This is the common mistletoe on oak in the southwestern United States and adjacent northern Mexico (Wiens, 1964). Along Highway 666, 16 miles north



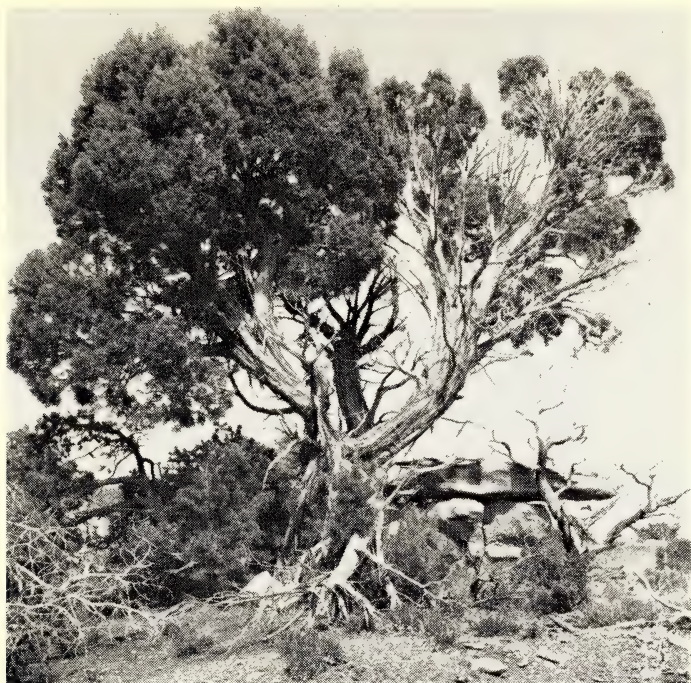


FIG. 3. Witches'-broom on *Juniperus osteosperma* associated with *Phoradendron juniperinum*. The left branch is a massive broom about 8 feet across. Twenty-six miles west of Blanding, San Juan Co., Utah. Photograph by R. S. Peterson, U. S. Forest Service.

of Clifton, Greenlee Co., Arizona, *P. villosum* ssp. *coryae* was found on several bushes of *Condalia globosa* Johnston var. *pubescens* Johnston (Hawksworth & Lightle 138, FPF). The parasite was common nearby on associated *Quercus turbinella* Greene.

*Phoradendron juniperinum* Engelm. ssp. *juniperinum*. This mistletoe is a common parasite of *Juniperus* from Oregon and Colorado south to northern Mexico (Wiens, 1964). Hedgcock (1915) noted that it had been "reported on *Cupressus arizonica*," although he had not seen collections of it on this host. We have examined the following specimens of *P. juniperinum* ssp. *juniperinum* on *Cupressus arizonica*: Cochise Co., Chiricahua National Monument (Gill FP 89611, FPF) and Chiricahua Mountains, Rucker Canyon (Hawksworth & Peterson 803 FPF). Mexico: Chihuahua, 38 miles southwest of Matachic on Ocampo Road (Wiens 3439, COLO and Hawksworth 482, FPF, INIF).

This mistletoe also occurs occasionally on *Cupressus bakeri* Jeps. in California: Plumas Co., 1.5 miles west of Wheeler Peak, east of Greenville (Quick 62-93, CAS); Shasta Co., 2 miles east of Burney Springs

(Peterson 65-458, FPF). In the latter locality, *P. juniperinum* was associated with *P. bolleanum* ssp. *densum*.

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#### NOTES AND NEWS

The Hafner Publishing Company, 31 East 10th Street, New York, New York 10003, has recently reprinted several books of interest to botanists. The photographic reproductions are of a very good quality and the cloth bindings are stout. Among the facsimile editions are: *Flora of Bermuda*, by N. L. BRITTON, \$12.00; *Flora of the Hawaiian Islands*, by WILLIAM HILLEBRAND, \$20.00; *Liberty Hyde Bailey*, by A. D. RODGERS, \$10.00; *Flora of the Prairies and Plains of Central North America*, by P. A. RYDBERG, \$12.00; *Life of Mendel*, by HUGO ILTIS, \$5.75; *Taxonomic Terminology of the Higher Plants*, by H. I. FEATHERLY, \$4.25; and *Plant Sociology, the Study of Plant Communities*, by J. BRAUN-BLANQUET, \$8.00.

Botany



# MADRÑO

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## CHRYSOTHAMNUS BOLANDERI, AN INTERGENERIC HYBRID

LORAN C. ANDERSON AND JACK L. REVEAL

The genus *Chrysothamnus* (Astereae, Compositae) is closely related to *Haplopappus*, and, particularly, *C. bolanderi* (Gray) Greene has been noted for its similarity to *H. macronema* Gray (section *Macronema*). Gray (1873) and Greene (1895) both suggested *C. bolanderi* could easily be placed in the other genus, and later Greene (1904) did so as *Macronema bolanderi*. This close resemblance to a species of *Haplopappus* makes the identification of *C. bolanderi* essential to an understanding of the systematics and evolution of *Chrysothamnus*. This plant has been, unfortunately, rarely collected. In addition to the earlier collections: *Bolander 6137* in 1866 (GH—holotype, UC!, US!) and *Rattan s. n.* in 1867 (DS!, mixed, *H. macronema* in part), it is now represented by *Reveal 1057* (KSC) and *Anderson & Fish 2923* and *2926* (KSC).

Bolander's type collection is labeled: "At Mono Pass, California, elevation 9000–10000 ft." The only plants we found after extensive independent search (Reveal in 1964, Anderson in 1965) were located east of Mono Pass (elevation 10604 ft.) in Bloody Canyon where they were restricted to a small oasis surrounded by barren rock. A small population was found at 10000 ft. on a steep talus-filled crevasse which rises abruptly from the northwest edge of Lower Sardine Lake (ca. 8 air miles southwest of Lee Vining). A few more plants were found in talus along the trail just below the lake at 9800 ft. A total of 25–50 plants, then, represents the extent of *C. bolanderi*.

Hall (Hall and Clements, 1923) described this taxon as a relict subspecies derived from *C. parryi* (Gray) Greene ssp. *parryi*. However, recent studies (Sharp and Birman, 1963) show that five advances of upper Pleistocene glaciation can be recognized in Bloody Canyon; these are Tioga, Tenaya, and Tahoe (of the Wisconsin), Mono Basin (Illinoian?), and Sherwin (Kansan?). This history of recent repeated glaciation does not support the designation of *C. bolanderi* as a relict. An alternative, as indicated by the extremely limited range and the fact that the plants are growing in very close association with *C. nauseosus* (Pallas) Britt. ssp. *albicaulis* (Nutt.) Hall & Clem. and *H. macronema*, is that it is of recent hybrid origin.

To elucidate the relationship of *C. bolanderi*, comparative studies on gross morphology, cytology, and anatomy were undertaken. Since *C. nauseosus* and *H. macronema* both vary considerably throughout their ranges, only collections associated with *C. bolanderi* are dealt with here. Data collected for *C. parryi* ssp. *monocephalus* (Nels. & Kenn.) Hall & Clem. and *H. suffruticosus* (Nutt.) Gray, also found in Bloody Canyon, indicate they are not related to the problem.

## MATERIALS AND METHODS

Methods for gathering data and preparing materials have been previously outlined (Anderson, 1963). Permanent slides and herbarium specimens are filed at Kansas State University. Before detailed studies were begun, Reveal's collection, being a sampling of the entire *C. bolanderi* population, was segregated according to superficial resemblance into three categories by the senior author: *Reveal 1057A*, those plants most similar to *C. nauseosus*; *Reveal 1057B*, those most similar to the type collection (*Bolander 6137*); and *Reveal 1057C*, those most like *H. macronema*.

## DISCUSSION

*Morphology.* On the talus slopes below Mono Pass, *C. nauseosus* is a woody shrub, 2.5–4 dm tall; *C. bolanderi* is less shrubby and intermediate in size (2–3 dm), and *H. macronema* is suffrutescent from a woody caudex and 1.5–2 dm tall.

Several aspects of leaf morphology are compiled in Table 1. The arbitrary trichome frequency classes are easily determined under 10 $\times$  magnification; they range in series from absent, through occasional, sparse, moderate, and abundant to very abundant. For illustration of frequency classes, see Eiten (1963). Specificity of trichome types and structure permits their use in analysis of hybrids; sometimes they may be used as the primary basis for determination of hybrids (Carlquist, 1961). With *C. nauseosus* having essentially only nonglandular trichomes and leaves of *H. macronema* glandular ones, the trichome complement in specimens of *C. bolanderi* gives an excellent index to degree of intergradation. Leaves of *C. nauseosus* do have a few glandular hairs, but they are not visible under 25 $\times$  magnification because of the tomentum. Nonglandular trichomes on leaves of *Bolander 6136* (*H. macronema*) are distributed evenly over the leaf surface, whereas in *Reveal 1052* they are restricted to the midribs.

Leaf size and shape are also useful as indicators of the intermediacy of *C. bolanderi*. Leaves of plants most like *H. macronema* (*Reveal 1057C* and *Anderson & Fish 2926*) are larger than those found in either putative parental populations. Leaves of *H. macronema* are unique in having undulate margins.

Several characteristics of floral morphology in *Chrysothamnus* have been demonstrated to be of diagnostic value (Anderson, 1946). Many which apply here are tabulated in Table 2 (omissions due to immaturity of specimens). Other features are discussed in the text.

The inflorescence of *C. nauseosus* is densely corymbose; that of *C. bolanderi* contains fewer heads, and *H. macronema* has a few or sometimes only a single head in the inflorescence. Heads are illustrated for the three taxa in Fig. 1. Involucre height and especially bract number indicate intergradation; further indications are found in bract alignment and structure. Bracts of *C. nauseosus* are in pronounced vertical ranks (a key character for the genus), keeled, and chartaceous. Those of

TABLE 1. COMPARATIVE FEATURES OF LEAF MORPHOLOGY

Taxon and collection	size, mm	shape	apex	trichome frequency	
				glandular	nonglandular
<i>C. nauseosus</i>					
<i>Anderson &amp; Fish 2924</i> (KSC)	27-30 x 1.5-2	linear-oblanceolate	acute-obtuse	absent	very abundant
<i>Bolander 6138</i> (US)	25-35 x 2-3	linear-oblanceolate	acute	absent	very abundant
<i>Reveal 1059</i> (KSC)	30-35 x 2-3	linear-oblanceolate	acute	absent	very abundant
<i>C. bolanderi</i>					
<i>Reveal 1057A</i> (KSC)	30-35 x 2-2.5	linear-oblanceolate	acute-acuminate	occasional	abundant
<i>Anderson &amp; Fish 2923</i> (KSC)	25-28 x 2.5-3.5	linear-oblong	attenuate-cuspidate	sparse	moderate
<i>Bolander 6137</i> (US)	28-33 x 3-4	oblong-oblanceolate	acuminate	moderate	sparse
<i>Reveal 1057B</i> (KSC)	30-37 x 3-4	oblong	acuminate	moderate	sparse
<i>Anderson &amp; Fish 2926</i> (KSC)	30-35 x 5-7	oblong-oblanceolate	obtuse, mucronate	moderate	sparse
<i>Reveal 1057C</i> (KSC)	30-45 x 4-7	oblong-oblanceolate	obtuse, mucronate	moderate	occasional
<i>H. macronema</i>					
<i>Bolander 6136</i> (MO)	23-30 x 4-5	oblong	acuminate	abundant	occasional
<i>Reveal 1052</i> (KSC)	22-24 x 3-5	oblong	acute	abundant	occasional
<i>Anderson &amp; Fish 2922</i> (KSC)	22-24 x 3-4	linear-oblong	acuminate	abundant	absent

*C. bolanderi* are in obscure vertical ranks, less prominently keeled, and more membranous. Bracts of *H. macronema* are not vertically aligned; they lack keels, and the outermost are green, leaf-like, and covered with glandular trichomes (not shown in Fig. 1).

Elsewhere throughout its range *C. nauseosus* is consistently 5-flowered; therefore, in the case of *Anderson & Fish 1924*, there is evidence of introgression. In addition to flower number, shape of the corolla tubes also suggests intergradation; they gradually flare out in *C. nauseosus*, are somewhat dilated in *C. bolanderi*, and more noticeably so in *H. macronema*. The collections most like *H. macronema* in gross appearance and trichome frequencies are, interestingly, more like *C. nauseosus* in floral morphology.

*Cytology.* Chromosome numbers as determined from pollen mother cells in meiosis are listed in Table 2; in each taxon,  $n = 9$ . Chromosomal pairing and other aspects of meiosis appear to be regular in *C. bolanderi*. Pollen fertility as determined by stainability in aniline blue in lactophenol is also listed in Table 2. Apparently normal meiosis and noticeably reduced pollen fertility also characterize the only other presumed hybrid known in *Chrysothamnus* (Anderson, 1966). The relatively high pollen fertility in *Reveal 1057A* is possibly due to back-crossing with *C. nauseosus*; this conclusion is supported by many similarities in morphology as reported here. Backcrossing with *H. macronema* is also indicated; the reduced pollen fertility of *Bolander 6136* suggests less compatibility between this parent and *C. bolanderi*. However, these variations in fertility and morphology could also be due to genic recombinations in the  $F_2$ .

The extent of viable seed formation in *C. bolanderi* has not been determined. Only one seed of *Reveal 1057C* successfully germinated, and the seedling died a few days later.

*Anatomy.* Vegetative anatomy, excluding features of the wood, is similar in most respects among the three taxa. The amounts of primary phloem sclerenchyma tend to vary according to topography and age of the sample; nevertheless, phloem fibers appear to be most abundant in stems of *H. macronema* and least abundant in *C. nauseosus*, with *C. bolanderi* appearing intermediate. Quantitative differences in trichome distribution have already been noted; in addition, there are differences in trichome size and structure. On stems of all samples there are uniseriate nonglandular hairs that are anisotropic under polarized light and biseriate glandular hairs that are isotropic. On stems of *C. nauseosus* the long uniseriate trichomes that form the tomentum cover the less frequent biseriate glandular hairs, the longest glandular hairs being only  $9.8 \mu$  long. In *C. bolanderi*, the longest glandular trichomes are  $12.7$  and  $13.2 \mu$  (*Anderson & Fish 1923* and *1926* respectively); whereas on stems of *H. macronema* the longest glandular trichomes are  $32.2 \mu$ .

A similar correlation exists for foliar trichomes with one interesting modification. On leaves of *C. nauseosus* the longest glandular trichomes



TABLE 2. COMPARATIVE FEATURES OF THE INVOLUCRE AND FLOWER

Taxon and collection	average bract number	range in bract number	average length of involucre, mm	average flower number	range in flower number	average flower length, mm	% lobe length to total flower length	% appendage length to total style length	gametic chromosome number	% pollen fertility
<i>C. nauseosus</i>										
Reveal 1059 (KSC)	10.0	9-11	8.5	5	5	10.1	18.8	57.2		98.7
Bolander 6138 (US)	11.0	9-12	10.4	5	5	11.0	18.3	52.3		92.3
Anderson & Fish 2924 (KSC)	12.3	11-13		6.4	6-7				9	
<i>C. bolanderi</i>										
Reveal 1057A (KSC)	12.6	12-14	9.5	7.2	6-9	8.5	15.3	58.8		94.0
Reveal 1057C (KSC)	13.5	11-17	12.0	7.4	6-9	10.2	22.5	55.7		34.9
Anderson & Fish 2926 (KSC)	12.5	11-14		8.2	5-13				9	
Reveal 1057B (KSC)	13.5	12-15	14.0	10.0	7-11	8.6	16.2	69.2		32.0
Bolander 6137 (US)	14.1	11-19	10.0	11.0	8-16	10.0	15.0	68.5		33.1
Anderson & Fish 2923 (KSC)	14.7	13-17	10.0	11.3	10-13				9	42.6
<i>H. macronema</i>										
Bolander 6136 (MO)	14.9	11-18	12.1	13.8	8-19	10.3	13.4	69.0		76.4
Reveal 1052 (KSC)	15.4	13-19	11.6	14.9	10-23	10.0	14.0	72.2		98.9
Anderson & Fish 2922 (KSC)	15.7	10-24	12.0	20.4	11-37	9.0	11.1	67.0	9	96.2

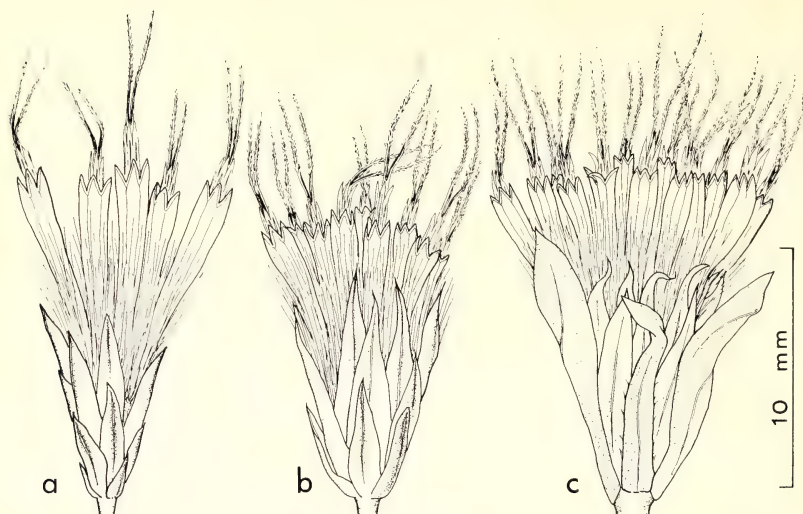


FIG. 1. Representative heads: a, *C. nauseosus*; b, *C. bolanderi*; c, *H. macronema*.

measure  $7.3 \mu$  and on *C. bolanderi*, 10.4 and  $12.0 \mu$ . The anisotropic uniseriate, nonglandular trichomes characteristic of leaves of the preceding are converted on *H. macronema* leaves into uniseriate glandular trichomes which are isotropic. These uniseriate glandular hairs are equally as long as the biseriates, the longest measuring  $25.0 \mu$ .

Selected characteristics of the wood anatomy for the three taxa are summarized in Table 3. The plus symbol indicates the feature is abundantly present, and the minus, present but not abundant. In nearly all features listed in Table 3, *C. bolanderi* is intermediate. Additional xylem features either indicate the possible hybridity of *C. bolanderi* or demonstrate it is more like *Chrysothamnus* than *Haplopappus*.

Vessels in the *Chrysothamni* are angular as seen in transection and appear in large groups of 10 or more; whereas in *H. macronema*, they are roughly circular in transection and average 4.09 per group. Terminal elements of a year's growth are vascular tracheids in each case, but in *H. macronema* they are less abundant; this coupled with other cellular patterns makes age determination of *H. macronema* wood difficult. Uniseriate rays are not frequent in woods of these two genera (Carlquist, 1960); in our samples they are occasional in *H. macronema*, less frequent in *C. bolanderi*, and extremely rare in *C. nauseosus*. Axial wood parenchyma is mostly vasicentric and scanty, being most abundant in *C. nauseosus* and least abundant in *C. bolanderi*.

Most features of floral anatomy are similar in the taxa; however, two are of significance. These are relative abundance and distribution of sclerenchyma in the phyllaries and distribution of secretory canals in the achenes and corollas. Sclerenchyma is less abundant in the phyllaries

TABLE 3. COMPARATIVE FEATURES OF THE WOOD

Taxon and collection	diameter of widest vessel, $\mu$	average diameter of vessels, $\mu$	average length of vessels, $\mu$	average height of multiseriate rays, mm	ray cells isodiametric to procumbent	ray cells isodiametric to erect	average number of cells of maximum multiseriate ray width	average number of rays per mm of tangential section
<i>C. nanuseosus</i>								
Anderson & Fish 2924 (KSC)	74.9	47.2	105.4	1.07	+	—	11.8	3.8
<i>C. bolanderi</i>								
Anderson & Fish 2923 (KSC)	81.7	46.5	107.7	1.31	+	—	9.1	4.3
Anderson & Fish 2926 (KSC)	99.9	57.6	109.6	1.35	+	—	6.9	4.2
<i>H. macronema</i>								
Anderson & Fish 2922 (KSC)	102.2	64.3	141.1	1.08	+	+	4.7	5.2

of *H. macronema* as compared to the *Chrysothamni*, *C. bolanderi* again being intermediate. Secretory canals are absent in achenes and flowers of *H. macronema*. They are equally abundant in achenes and style branches in our *Chrysothamnus* samples, but in the corollas they are more extensive in *C. nauseosus*, where they are in the distal portion of the corolla tube as well as in the corolla lobes as in *C. bolanderi*.

#### CONCLUSIONS

Absolute proof of hybridity, the successful synthesis of *C. bolanderi* from artificially crossing *C. nauseosus* and *H. macronema*, is lacking. Nevertheless, sufficient circumstantial evidence has been amassed from field observations and studies on morphology, cytology, and anatomy to strongly indicate that *C. bolanderi* is indeed a hybrid swarm. Back-crossing, particularly with *C. nauseosus*, is also indicated. In nearly all features, *C. bolanderi* is intermediate; however, in some collections, features such as taller wood rays and larger leaves and involucre suggest a complementary genic action in the hybrids.

Secondly, floral anatomy and especially the wood anatomy of the hybrids is more like that of *Chrysothamnus* than of *Haplopappus*. Therefore, if the genera are treated as distinct, the hybrids should be placed in *Chrysothamnus*. The overall appearance of *C. bolanderi* is that of a subspecies of *C. parryi*. In fact, it is currently treated as *C. parryi* ssp. *bolanderi* (Gray) Hall & Clem. in all floras. Nevertheless, since infra-specific taxa of *C. parryi* are not involved in the origin of this taxon, it is better referred to as *C. bolanderi*.

The hybrid origin of *C. bolanderi* was discovered in preparation of a monograph on *Chrysothamnus* by the senior author. The taxonomic status of the genus in light of this intergeneric hybridization will be considered in the monograph.

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## A NEW SPECIES OF BRODIAEA FROM SAN CLEMENTE ISLAND, CALIFORNIA

THEODORE F. NIEHAUS

The island of San Clemente off the southern California coast is noted for its high number of endemics (Raven, 1963). A new species here reported raises the total number of endemics on San Clemente I. to eleven.

***Brodiaea kinkiensis*** Niehaus, sp. nov. Planta ex cormo tunica fibrosa instructo; perianthii tubo 12 mm longo, 4-5 mm lato, basi rotundato, ejus segmentis patentibus 13-17 mm longis, eis exterioribus oblongis, interioribus obovatis; staminodia paulo involuta, 3 mm lata, 7 mm longa, apice cuspidata, erecta, a staminibus distantia; capsula oblonga; perianthii tubo demum haud fisso.

Corm with heavy fibrous outer coat; leaves linear, 2-4 dm long; scape 2-3 dm tall; pedicels 3-8 cm long; perianth-tube whitish with brown-purple midribs extending to tips of the segments, rounded at the base, 12 mm long and 4-5 mm wide; perianth-segments violet, 13-17 mm long, spreading at right angles to perianth-tube; outer segments oblong, inner ones obovate; staminodia slightly involute, 3 mm wide, 7 mm long, apically cuspidate, standing erect and well apart from stamens; filaments 1 mm long, anthers retuse, channeled on back, 4-5 mm long; capsule oblong; perianth-tube not splitting as capsule matures; chromosome number  $2n = 32$ .

Holotype. 0.5 mi W of Stone at junction of road to Stone with main island axis road, San Clemente I., Los Angeles Co., 1395 ft., April 3, 1965, T. F. Niehaus 407 (UC, 1200400).

*Brodiaea kinkiensis* is known at present only from San Clemente I. One previous and fragmentary collection was cited as *B. filifolia* Wats. by Hoover (1939) (*Murbarger* 219, UC). It is probable that *B. kinkien-*

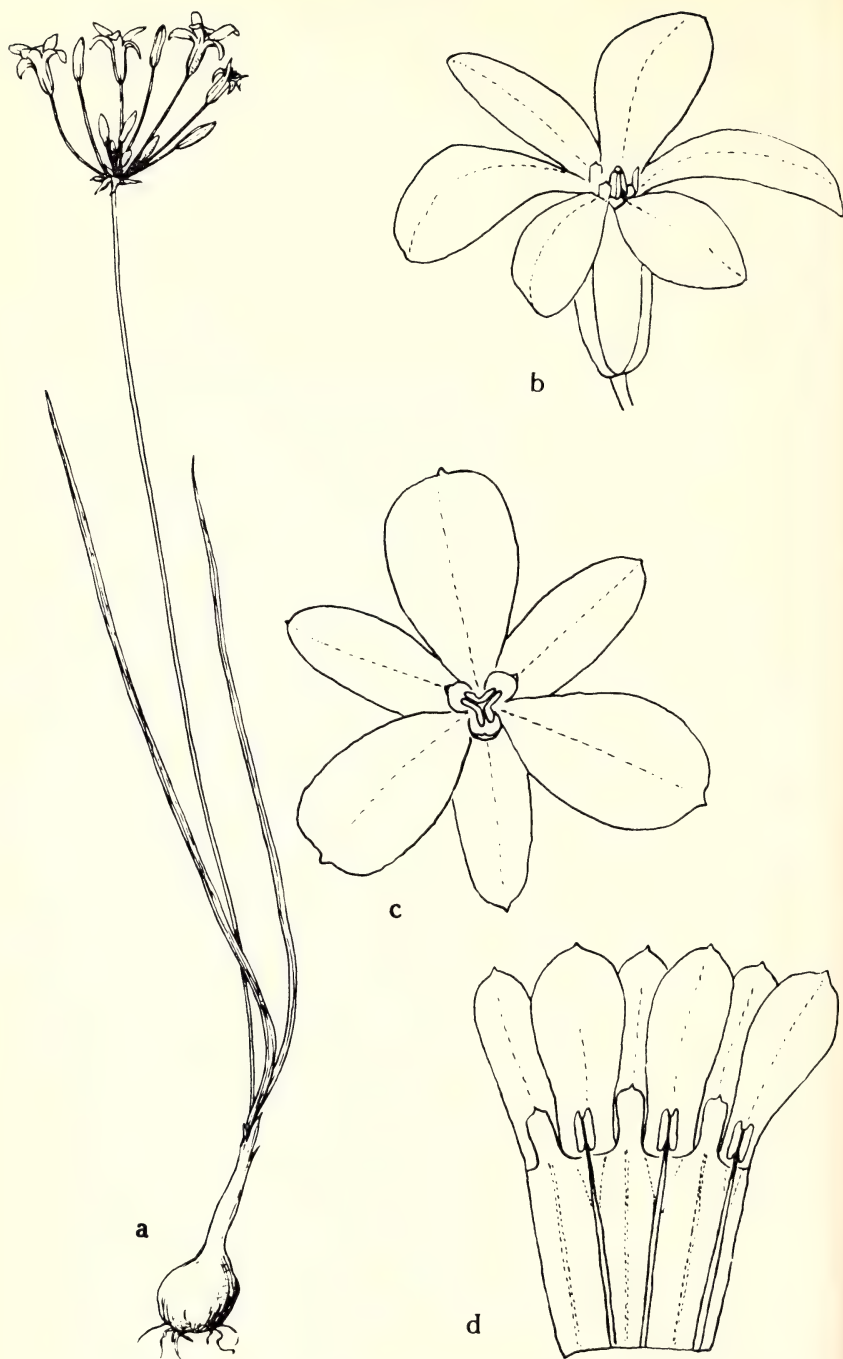


FIG. 1. *Brodiaea kinkiensis*: a, habit,  $\times \frac{1}{3}$ ; b, individual flower,  $\times 2$ ; c, overhead view,  $\times 2$ ; d, interior arrangement,  $\times 2$ .

*sis* is most closely related to *B. filifolia*. *Brodiaea kinkiensis* may be distinguished from *B. filifolia* by the very coarse and thick fibrous outer coat of its corm, its longer perianth-tube (that of *B. filifolia* being 6–7 mm in length), and its erect cuspidate much wider staminodia (those of *B. filifolia* being much shorter and virtually obsolescent and capillary). Continued research on the probable relationships and on other questions is under way for the entire genus.

*Brodiaea kinkiensis* was collected by the author and Wayne Roderick, April 1–4, 1965, at which time it was in bud. Corms were grown at the University of California Botanic Garden where I ultimately obtained flowering specimens. This species was observed to be common in the clay flats on the mesa of the island from near Lemon Tank south to Boulder, a distance of about 4 miles. It undoubtedly occurs farther to the north and south along the mesa-top. A chromosome count of  $2n = 32$  (Niehaus, 1965) was reported (as *B. filifolia*) for *B. kinkiensis*. This was previous to my having seen living material of the mainland species, *B. filifolia*, and having compared it with that growing on San Clemente Island. As of this date, *B. filifolia* now remains the only species of *Brodiaea* (as defined by Hoover) for which a chromosome count still remains to be made.

The specific epithet is based on the word “*kinki*,” the Gabrielino Indian name for San Clemente I. (Kroeber, 1925).

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# CHROMOSOME NUMBERS IN THE *ERIOPHYLLUM LANATUM* (COMPOSITAE, HELENIEAE) COMPLEX

JOHN S. MOORING

*Eriophyllum lanatum* (Pursh) Forbes is a species-complex consisting of at least 10 ill-defined regional varieties that range from southern California to British Columbia, Montana and Wyoming. Constance (1937) noted that of the 157 binomials and trinomials which had been applied to members of *Eriophyllum*, 75 were referable to *E. lanatum*. Carlquist (1956) recorded chromosome counts of  $n = 8$  and  $n = 16$  in 2 of the varieties of *E. lanatum*, and observed that additional studies should prove interesting. My interest in the *E. lanatum* complex stems partly from my studies of the *Chaenactis douglasii* complex (Mooring, 1965; and unpublished). Both of these Helenieae have approximately the same geographic distribution, ecologic amplitude, life span and degree of taxonomic complexity. Among other items, I wished to compare the geographic distribution of diploids and polyploids in *E. lanatum* with that known for *C. douglasii*, in which a remarkable correlation exists between ploidy level and geographic distribution.

The purpose of this paper is to present the chromosome counts obtained in the first part of this study, and to suggest the direction of further research.

I appreciate the support afforded by National Science Foundation Research Grant GB-3338, and the stimulating accounts of *Eriophyllum* by Constance (1937) and Carlquist (1956).

## MATERIALS AND METHODS

Young heads from wild or garden plants were fixed either in 1:3 acetic-alcohol or in 1:3:6 acetic-chloroform-alcohol. Chromosome counts were obtained from pollen mother cells squashed in acetocarmine. Specimens have been deposited in the University of Santa Clara Herbarium and replicates of most of them will be distributed elsewhere.

## RESULTS

Table 1 shows my chromosome counts. Figure 1 shows my counts, those of Carlquist (1956) and one provided by Peter Raven (letter). The counts of  $2n = c. 48$  in *E. lanatum* var. *achillaeoides*, all the counts in vars. *aphanactis*, *croceum*, *cuneatum*, *integrifolium*, *lanatum*, *lanceolatum* and *leucophyllum*, and those for the putative hybrid between var. *arachnoideum* and *E. confertiflorum* are first reports. Meiosis was sometimes unclear in PMC's from wild plants, especially at the tetraploid and hexaploid level. Bivalents seemed the rule, although 1028 and 1032 had an occasional association of 4 chromosomes, 1455, 1590, 1642 and Raven 20294 each had a small supernumerary chromosome, and 1024 had a small pair of extra chromosomes.



TABLE 1. CHROMOSOME COUNTS IN ERIOPHYLLUM

Collection numbers are my own, unless otherwise stated.

*E. lanatum* (Pursh) Forbes var. *lanatum*.  $2n = 16$ . Idaho. Idaho Co., Kamiah, 1122. Oregon. Wallowa Co., Grand Ronde Canyon, 1107. Washington. Clark Co., Battleground, 1586; Yakima Co., American River, 1600.

var. *achillaeoides* (DC.) Jepson.  $2n = 16$ . California. Contra Costa Co., Mt. Diablo, 1028; Glenn Co., Stonyford, 1532; Humboldt Co., Garberville, 1574; Santa Clara Co., Loma Prieta, 1375; Siskiyou Co., Grass Lake, 1676; Trinity Co., Douglas City, 1495. Oregon. Klamath Co., Modoc Point, 1665.  $2n = 32$ . California. Colusa Co., Leesville, 1535; Tehama Co., Beegum, 1517.  $2n = c. 48$ . California. Mendocino Co., Hopland, 1032.

var. *aphanactis* Howell.  $2n = 32$ . California. Glenn Co., Elk Creek, 1520; McGrew Springs, 1525.

var. *arachnoideum* (Fisch. & Ave.-Lall.) Jepson.  $2n = c. 16$ . California. San Mateo Co., Bear Gulch Road, 1557.

var. *croceum* (Greene) Jepson.  $2n = 32$ . California. Nevada Co., Banner Hill, 1002, 1005.

var. *cuneatum* (Kell.) Jepson.  $2n = c. 32$ . California. Nevada Co., Cisco Grove, 1150, 1151.

var. *grandiflorum* (Gray) Jepson.  $2n = 16$ . California. Amador Co., Jackson, 1467; Calaveras Co., Murphys, 1455; Del Norte Co., Klamath Glen, 1039, 1040, 1043; Idlewild, 1048; El Dorado Co., Pollock Pines, 1471; Mariposa Co., Bagby, 1430; Nevada Co., Banner Hill, 1010; Placer Co., Auburn, 1021; Shasta Co., Whiskeytown Creek, 1490; Platina, 1510; Siskiyou Co., Black Butte Summit, 1681; Trinity Co., Douglas City, 1502; 1506; Tuolumne Co., Stent, 1445; Twainharte, 1450.  $2n = 32$ . California. Butte Co., Oroville, 1476; Shasta Co., Millville, 1481.

var. *integrifolium* (Hook.) Smiley.  $2n = 16$ . California. Tuolumne Co., Kennedy Meadows, Raven 20294 (DS). Idaho. Owyhee Co., Jump Creek Canyon, 1351, 1352. Oregon. Baker Co., Dooley Mountain, 1094; Deschutes Co., Sisters, 1059; La Pine, 1642; Grant Co., Canyon City, 1079; Klamath Co., Collier State Park, 1650. Wyoming. Fremont Co., Togwotee Pass, 1301.

var. *lanceolatum* (Howell) Jepson.  $2n = 16$ . California. Trinity Co., Mountain Meadows Ranch, 1712. Oregon. Josephine Co., Oregon Caves, 1053.

var. *leucophyllum* (DC.) W. R. Carter.  $2n = 32$ . Washington. Lewis Co., Toledo, 1590.

var. *arachnoideum* (Fisch. & Ave.-Lall.) Jepson  $\times$  *E. confertiflorum* (DC.) Gray. California. San Mateo Co., Black Mountain, 1024 ( $2n = c. 32-40$ ), 1027 ( $2n = 50$ ).

*E. confertiflorum* (DC.) Gray.  $2n = 16$ . California. Los Angeles Co., La Cañada, 5525 Alta Cañada, 1365; San Bernardino Co., Fredalba, 1360.

## DISCUSSION

At this time my results merely extend the investigations begun by Constance (1937) and Carlquist (1956). *Eriophyllum lanatum* var. *grandiflorum* includes diploids and tetraploids, and var. *achillaeoides* diploids, tetraploids and hexaploids. The other varieties of the *E. lanatum* complex for which counts are available appear to consist of diploids (*arachnoideum*, *integrifolium*, *lanatum*, *lanceolatum*) or of tetraploids (*aphanactis*, *croceum*, *cuneatum*, *leucophyllum*). My 2 counts for *E. confertiflorum* are in line with Carlquist's (1956) results:  $n = 8$  for southern California mainland material. Further counts may well change these impressions.

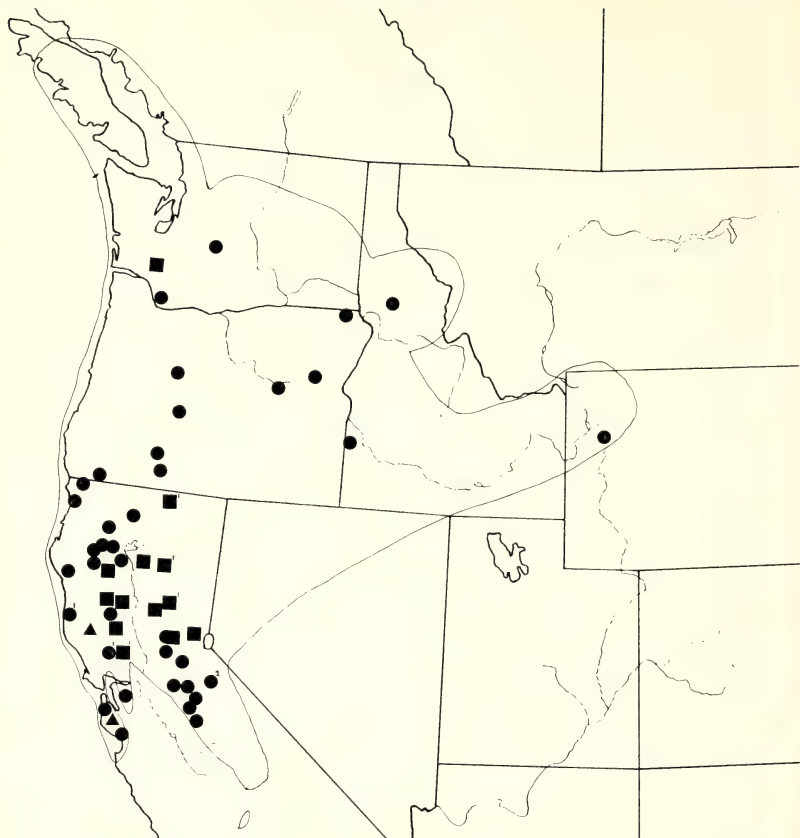


FIG. 1. Distribution of diploids (circles), tetraploids (squares) and hexaploids (triangles) in the *E. lanatum* complex. Symbols marked "1" derived from Carlquist (1956), that marked "2" of Raven 20294, all other counts my own. Range of the complex shown in outline.

The paucity of chromosome counts provides small basis for speculation about the evolutionary role of polyploidy in the *E. lanatum* complex. In most instances only one plant per population has been examined cytologically. So far, however, only one polyploid has been found outside California, and no evidence exists that polyploidy has been mainly responsible for the development of the complex as a whole. Available data do suggest, however, that polyploidy has contributed occasionally, sometimes by promoting interbreeding and elsewhere by inhibiting it. For example, var. *cuneatum* may be of allopolyploid origin. It is in many ways intermediate between vars. *grandiflorum* and *integrifolium*, and occurs in a relatively narrow zone between them. Chromosome counts of Cisco Grove plants show them to be tetraploids, whereas counts in *grandiflorum* and *integrifolium* reveal only diploids, at least near the range of *cuneatum*. Polyploidy also may have promoted morphologic

divergence by decreasing interbreeding where varieties exist sympatrically. At Banner Hill, where they grow in a mixed colony, vars. *croceum* and *grandiflorum* differ sharply morphologically, phenologically and chromosomally, and, to a lesser extent, ecologically. Counts show *croceum* to be tetraploid and *grandiflorum* diploid. Varieties *achillaeoides* and *aphanactis* may represent a similar situation. The latter apparently is essentially a rayless expression of the former, but counts show it to be tetraploid, whereas, *achillaeoides* may be diploid, tetraploid or hexaploid. Elsewhere, however, varieties may exist sympatrically or nearly so, maintain their integrity, and yet have, apparently, the same chromosome number. This appears to be the situation near Weaverville and near Weed for vars. *achillaeoides* and *grandiflorum*. It is quite clear that much additional work is needed before much can be said about either the role of polyploidy in the complex or the taxonomic status of the "varieties." The foregoing remarks merely represent possible conclusions to be drawn from the scanty data, and suggest the direction of future research. Obviously, much remains to be done, especially in northwestern California-southwestern Oregon, the central Sierra Nevada, and in the synonymy-ridden and wide-ranging var. *integrifolium*.

*Eriophyllum lanatum* apparently hybridizes with *E. confertiflorum* (Constance, 1937; Thomas, 1961), and *E. jepsonii* Greene and *E. latilobum* Rydb. possibly arose, independently, from these sources (Constance, 1937; Munz, 1959). I have found 2 localities where *E. lanatum* apparently hybridizes with *E. confertiflorum*. In one it is via var. *arachnoideum*, in the other via var. *achillaeoides*. The former population is the source of the  $2n = 32-40$  and  $2n = 50$  counts in Table 1. These populations will receive further study.

*Eriophyllum* seems to be a rapidly evolving genus. The *E. lanatum* complex appears to be ancestral or near-ancestral to the rest of the genus, and perhaps to *Monolopia* and other closely related genera as well, as Constance (1937), without benefit of chromosome number information, speculated a generation ago. Hopefully, further study will clarify the biologic and taxonomic situation in the *E. lanatum* complex, and perhaps lead to a better understanding of *Eriophyllum* and of the subtribe Eriophyllanae.

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## PROPAGATION OF SOME WOODY DESERT PERENNIALS BY STEM CUTTINGS

VALERIE C. CHASE AND B. R. STRAIN

Vegetatively propagated material provides an excellent control parameter in investigations of the effect of various environmental factors on plant growth. Clonal plants from a single ortet, grown under various natural or controlled environments, may be compared with some assurance that the elicited morphological or physiological differences are environmentally induced and not caused by genetic variation (Heslop-Harrison, 1964).

It is well known that desert succulents may be propagated by stem cuttings (many members of *Cactaceae*), rhizomes (certain members of the genus *Yucca*), or plantlets (*Agave* and *Kalanchoae*). Little has been published, however, about vegetative propagation of woody desert perennials. Although a relatively recent report (Shreve, 1951) stated that *Fouquieria splendens* was the only woody perennial of the Sonoran Desert which could be propagated by stem cuttings, more recent work with *Chilopsis linearis* (Everett, 1957) and *Simmondsia chinensis* (Gentry, 1958) indicates that other desert shrubs may be propagated by stem cuttings.

The general lack of information concerning vegetative propagation of woody desert perennials prompted the testing of some predominant desert shrubs and trees to determine which propagating techniques could be used to obtain clonal material for a proposed comparative physiological-ecological analysis of desert perennials.

Stem cuttings from 11 woody perennial species (table 1) were collected near Palm Springs, California on March 7, 1965 and from nine species (table 2) on June 9, 1965. The cuttings were transported to the laboratory in plastic bags containing a little water.

The cuttings of each species of the first collection were divided into four equal lots, a fresh cut made, and the basipetal 1 inch placed in solutions of indole-3-acetic acid (IAA) for 24 hours (Audus, 1959). Two lots were treated with 200 ppm IAA, and one lot each with 100 and 300 ppm IAA.

The cuttings of one of the 200 ppm lots were suspended in an aerated nutrient solution (half-strength Hoagland's). The solution was changed weekly.

The remaining three lots were planted in vermiculite in a rooting box. All the cuttings were maintained on a 24 hour photoperiod (Lanphear and Meahl, 1961; Baker and Link, 1963), the natural light being supplemented by fluorescent bulbs. The intensity of the artificial light ranged from 150 to 200 ft-c at plant level. The rooting box was provided with bottom heat of 70° F by a thermistated heating tape (Audus, 1959).



TABLE 1. PERCENTAGE ROOTING OF CUTTINGS TAKEN MARCH 7. THE NUMBERS IN PARENTHESIS INDICATE THE NUMBER OF CUTTINGS IN EACH LOT

Species	100 ppm	IAA concentration	
		200 ppm	300 ppm
<i>Acacia greggii</i> Gray	0 (13)	0 (13)	0 (13)
<i>Cercidium floridum</i> Benth.	0 (20)	0 (20)	0 (20)
<i>Dalea schottii</i> Torr.	0 (20)	0 (20)	0 (20)
<i>Encelia farinosa</i> Gray #1	0 (10)	10 (10)	0 (11)
#2	82 (11)	72 (11)	70 (10)
<i>Ephedra californica</i> Wats.	0 (20)	0 (20)	0 (20)
<i>Franseria dumosa</i> Gray	33 (6)	0 (6)	33 (6)
<i>Hymenoclea salsola</i> T. & G.	78 (23)	95 (20)	95 (20)
<i>Isomeris arborea</i> Nutt.	0 (20)	0 (20)	0 (20)
<i>Larrea divaricata</i> Cav.	0 (20)	0 (20)	0 (20)
<i>Prosopis juliflora</i> D.C.	0 (15)	0 (10)	0 (14)
<i>Simmondsia chinensis</i>	30 (20)	24 (20)	24 (20)

C. K. Schneid.

Each species of the second group of cuttings was divided into three lots. Two of the lots were placed in water for 24 hours while the remaining lot was soaked for 24 hours in IAA of 200 ppm. One of the water treated lots of each species was dipped in Rootone (Naphthylacetamide, 0.06%; 2-methyl-1-naphthylacetic acid, 0.033%; 2-methyl-1-naphthylacetamide, 0.013%; indole-3-butyric acid, 0.057%; inert ingredients, 99.85%), a commercial rooting powder, and the other lot was used as an untreated control. The cuttings were placed in the rooting box as outlined above. After rooting (48 days), the cuttings were transplanted into 4 inch pots in light greenhouse soil and returned to the rooting box to facilitate establishment.

The cuttings placed in the nutrient solution died within 30 days. No roots formed on any of the plants treated in this manner.

Daily maximum and minimum temperatures in the rooting box averaged 82 and 87 and 64 and 62 F during the first and second treatment periods respectively. The average maximum relative humidity was 86 and 85 per cent, and the average minimum relative humidity was 59 and 60 per cent during the first and second periods respectively.

In the first test, the percentage of rooting was high in *Hymenoclea salsola* and *Encelia farinosa* and fairly high in *Franseria dumosa* and *Simmondsia chinensis* (table 1). In this test, all of the cuttings of a species came from a single individual with the exception of *Prosopis juliflora* and *Encelia farinosa*. The cuttings of *Prosopis* were taken from eight plants, those from *Encelia* from two plants in the same stage of flowering, growing less than 10 ft apart. Only 1 of 31 cuttings of one shrub rooted while 24 of 32 cuttings of the neighboring bush formed roots, indicating the possibility of intraspecific physiological or genetic variation in the rooting response. Consequently, a random sampling technique, in which cuttings were taken from several plants, was employed in the second test.

TABLE 2. PERCENTAGE ROOTING OF CUTTINGS TAKEN JUNE 9. THE NUMBERS IN PARENTHESIS INDICATE THE NUMBER OF CUTTINGS IN THE LOT

Species	control	Rootone	200 ppm IAA
<i>Acacia greggii</i> Gray	0 (3)	0 (4)	0 (4)
<i>Chilopsis linearis</i> Sweet.	83 (6)	100 (5)	0 (5)
<i>Dalea schottii</i> Torr.	0 (10)	0 (10)	20 (10)
<i>Franseria dumosa</i> Gray	50 (10)	70 (10)	50 (10)
<i>Hymenoclea salsola</i> T. & G.	20 (10)	10 (10)	80 (10)
<i>Isomeris arborea</i> Nutt.	0 (10)	50 (10)	0 (10)
<i>Peucephyllum schottii</i> Gray	14 (7)	100 (8)	33 (6)
<i>Pluchea sericea</i> Gove.	20 (10)	0 (10)	20 (10)
<i>Simmondsia chinensis</i> C. K. Schneid.	10 (10)	0 (10)	10 (10)

The second group of cuttings was taken to determine the relative values of IAA and Rootone as rooting hormones. In this test, *Chilopsis linearis*, *Franseria dumosa*, *Hymenoclea salsola*, and *Peucephyllum schottii* rooted well. *Dalea schottii*, *Isomeris arborea*, *Pluchea sericea* and *Simmondsia chinensis* showed some degree of root formation (table 2). *I. arborea* and *D. schottii* had not rooted in the previous test.

The success with Rootone as a rooting substance and the relative ease of its application has precluded further work with IAA. *Hymenoclea salsola* is the only species that responded significantly better to IAA than to the commercial rooting powder.

#### CONCLUSIONS

1. Stem cuttings of many woody desert perennials can be induced to form roots, contrary to an earlier report (Shreve, 1951).
2. For most of the shrubs which rooted, maintenance of Rootone treated cuttings in a rooting box under continuous light with moderate bottom heat provides an acceptable percentage of rooting.
3. Treatment with 200 ppm indole-3-acetic acid may enhance rooting in cuttings which respond poorly to Rootone.
4. Some species, however, (*Acacia greggii*, *Cercidium floridum*, *Ephedra californica*, *Larrea divaricata* and *Prosopis juliflora*) did not root under any of our treatments.

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## NOTES ON THE HORDEUM JUBATUM COMPLEX

TIBOR RAJHATHY

Mitchell and Wilton (1964) examined the *jubatum-caespitosum-brachyantherum* complex in Alaska. Their report contains interesting information on the behaviour of the complex at the northern border of the North American population. They concluded that there is "little support for combining the Alaskan populations of *H. brachyantherum* with *H. jubatum*." If the word "Alaskan" is omitted then the conclusion is at variance with the one suggested by Rajhathy and Morrison (1959; 1961) and with the taxonomic treatment of this group by Bowden (1962). Although Mitchell and Wilton dealt with Alaskan populations which are only a small peripheral fraction of the whole North American population, they generalize from their data and propose to maintain species status for both *jubatum* and *brachyantherum*. Since in their generalization they disregard a mass of evidence obtained on the populations of the Canadian and American West and Midwest as well as in the experimental garden, a brief discussion of the problem seems to be warranted. This paper is contribution No. 139 from the Research Station, Canada Department of Agriculture, Central Experimental Farm, Ottawa.

Species relationships should be assessed in the light of the biological species concept. Thus, interbreeding should be recognized as the main criterion of conspecific status. Mitchell and Wilton stated that *H. brachyantherum* and *H. jubatum* fail to "hybridize on many sites where they are in contact." This appears to be the case in Alaska. Although they located a few hybrid populations, their future remains doubtful. The authors may be right because the extreme environment of Alaska may not provide the ecological niche for successful competition or introgression. However, even if this were the case, generalizing from a specialized peripheral situation cannot be considered valid. When interbreeding between two species populations is examined surely greater significance should be assigned to those sites where hybridization does occur than to those where it does not. Large hybrid swarms exist in the Canadian and American West and Midwest. These became well established also in areas such as Saskatchewan and Manitoba where only *H. jubatum* occurs and *brachyantherum* is absent (Bowden, 1962). Thus, they not only maintain themselves but also migrate from the original sites.



Hybridization is a prerequisite of interbreeding, the fertility of the hybrids being a more sensitive indicator of the degree of relationship than crossability alone. Using these in evaluating relationships the breeding system of the parental species and isolation mechanisms should be considered. Both *jubatum* and *brachyantherum* are inbreeders, hence it is not surprising that they do not hybridize at some sites of contact. Inhibited embryo development in interspecific hybrids is a very characteristic isolation barrier in the *Hordeum* genus (Rajhathy *et al.*, 1964). In view of this, the absence of this barrier in the *jubatum-brachyantherum* group must be considered very important. Some advanced generation hybrid strains are fertile to the extent that they are just as troublesome weeds as *H. jubatum*. Failure of seed set is not likely to be an isolation barrier even in Alaska where one plant in a relatively small sample had 47 per cent seed set. The chances for superior and fertile combinations are much better in nature than in the nursery where usually only a few genotypes are involved. A wide array of types segregate in  $F_3$  and  $F_4$  generations for awn length which is the best character differentiating the parental taxa. The natural hybrid swarms are more similar morphologically to *jubatum* than to *brachyantherum* because *jubatum* is usually the recurrent parent.

The abundance of natural hybrids and the partial fertility of the  $F_1$  hybrids in the nursery are indicative of a relatively regular gametogenesis. Some irregularities in chromosome pairings were noted in the hybrids (Rajhathy and Morrison, 1959). However, a sufficient amount of good pollen grains was produced to secure good seed set. Thus, it is surprising that Mitchell and Wilton were unable to record chromosome pairing at first metaphase because of the incidence of irregularities.

The taxonomic treatment of the *jubatum* group by Bowden was based on experimental results obtained by cytogenetical methods and reflected biological relationships. The interesting data of Mitchell and Wilton make the information more complete but do not change the overall pattern of species relationships in this important group.

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## DOCUMENTED CHROMOSOME NUMBERS OF PLANTS

(See Madroño 9:257-258. 1949; 17:255. 1964)

- Astranthium condimentum* De Jong.  $n = 3$ . Mexico, Jalisco, Mazamitla. *D. C. D. De Jong* 1675, MU; Michoacan, near Quiroga, *D. C. D. De Jong* 1656, MU; Michoacan, near Ario de Rosales. *D. C. D. De Jong* 1657, MU.
- A. orthopodium* (Robins. & Fern.) Larsen.  $n = 3$ . Mexico, Chihuahua, near Madera. *D. C. D. De Jong* 1769, MU; Durango, near Hacienda Coyotes. *D. C. D. De Jong* 1382, MU.
- A. purpurascens* (Robins.) Larsen.  $n = 8$ . Mexico, Chiapas, between Comitan and San Nicolas. *D. C. D. De Jong* 1419, MU; Chiapas, between Teopisca and San Cristobal las Casas. *D. C. D. De Jong* 1438, MU; Hidalgo, Puerto de Horcones. *D. C. D. De Jong* 1584, MU; Hidalgo, near Jacala. *D. C. D. De Jong* 1585, MU.
- A. xanthocomoides* (Less.) Larsen.  $n = 8$ . Mexico, Hidalgo, Elvado. *D. C. D. De Jong* 1535, MU; Hidalgo, Real del Monte. *D. C. D. De Jong* 1550, MU; Puebla, Laguna de Atezca. *D. C. D. De Jong* 1594, MU; Veracruz, near Magueyotos. *D. C. D. De Jong* 1607, MU.
- A. xylopodium* Larsen.  $n = 5$ . Mexico, Nayarit, near Compostela. *D. C. D. De Jong* 1690, MU.
- Baileya multiradiata* Torr.  $n = 16$ . Mexico, Chihuahua, near Ciudad Chihuahua. *D. C. D. De Jong* 1377, MU.
- Buddleia skutchii* Morton.  $2n = ca. 38_{II}$ . Mexico, Chiapas, Chamula. *D. E. Breedlove* 6654, DS, F. Counted by D. W. Kyhos.
- Chlorogalum pomeridianum* (DC.) Kunth.  $n = 15$ . California, Fresno Co. *H. M. Beard & W. Roderick*, 1961, JEPS. Counted by M. S. Cave.
- Cleome spinosa* Jacq.  $2n = 10_{II}$ . Mexico, Chiapas, Tuxtla Gutierrez. *D. E. Breedlove* 9193, DS, F. One pair was twice the size of the others as in the tetraploid *Cleome isomeris* (Nutt.) Greene (*Isomeris arborea* Nutt.). Counted by D. W. Kyhos.
- Coriaria thymifolia* Hum. & Bonpl. ex Willd.  $2n = 20_{II}$ . Mexico, Chiapas, Zinacantan. *P. H. Raven & D. E. Breedlove* 20142, DS. Fig. 1. Counted by D. W. Kyhos.

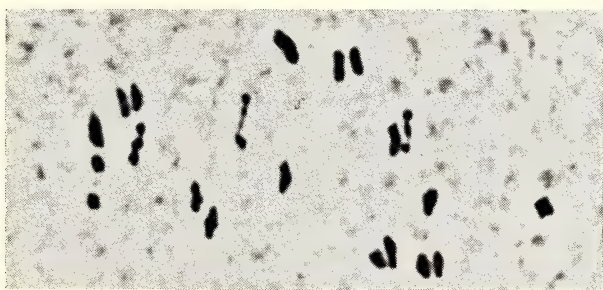


FIG. 1. *Coriaria thymifolia*,  $\times 1470$ .

- Erythronium tuolumnense* Appleg.  $n = 12$ . California, Tuolumne Co. *W. Roderick*, 1962, JEPS. Counted by M. S. Cave.
- Galphimia glauca* Cav.  $n = 6$ . Mexico, Chiapas, Pinola. *D. E. Breedlove* 7072, DS, F. Very large chromosomes. Adds a third basic number to the two ( $x = 9, 10$ ) already known for the Malphiaceae and suggests that the counts of  $n = 12$  in this family are tetraploid. Counted by D. W. Kyhos.
- Microspermum debile* Benth.  $n = 12$ . Mexico, Oaxaca, Ixtlan de Juarez. *D. C. D. De Jong* 1481, MU.

- Narthecium californicum* Baker. **n** = 13. Oregon, Josephine Co. *W. Roderick*, 1962, JEPS; *W. Roderick*, 1965, JEPS. Counted by M. S. Cave.
- Olivaia leptocarpa* De Jong & Beaman. **n** = 6. Mexico, Durango, near J. G. Aguilera. *D. C. D. De Jong* 1754, MU; *D. C. D. De Jong* 1760, MU.
- O. tricusps* Sch.-Bip. ex Benth. **n** = 6. Mexico, Jalisco, near Acatlan. *D. C. D. De Jong* 1687, MU; Jalisco, near Guadalajara. *D. C. D. De Jong* 1688, MU; State of Mexico, near Toluca. *D. C. D. De Jong* 1619, MU; *D. C. D. De Jong* 1650, MU; State of Mexico, Del Rio. *D. C. D. De Jong* 1647, MU; Nayarit, Tepic. *D. C. D. De Jong* 1693, MU.
- Schoenolirion album* Dur. **n** = 26. California, Plumas Co. *G. E. See*, 1957, JEPS. Counted by M. S. Cave.
- Spiranthes gracilis* (Bigel.) Beck. **n** = 15. Florida, Hillsborough Co. *R. W. Long* 1168, USF. Counted by M. S. Cave.
- Stenanthium occidentale* Gray. **n** = 8. California, Siskiyou Co. *W. Roderick*, 1962, JEPS; *W. Roderick*, 1965, JEPS. Counted by M. S. Cave.
- Tofieldia glutinosa* (Michx.) Pers. ssp. *occidentalis* (Wats.) Hitch. **n** = 15. Oregon, Josephine Co. *W. Roderick*, 1962, JEPS. Counted by M. S. Cave.
- Veratrum californicum* Dur. **n** = 16. California, Alpine Co. *W. Roderick*, 1965, JEPS; Eldorado Co. *H. G. Baker*, 1965, JEPS. Counted by M. S. Cave.
- V. fimbriatum* Gray. **n** = 16. California, Mendocino Co. *W. Roderick*, 1965, JEPS. Counted by M. S. Cave.
- V. insolitum* Jeps. **n** = 16. California, Siskiyou Co. *W. Roderick*, 1965, JEPS. Counted by M. S. Cave.
- Xerophyllum tenax* (Pursh) Nutt. **n** = 15. California, Mendocino Co. *W. Roderick*, 1965, JEPS. Counted by M. S. Cave.

## REVIEWS

THE HUNT BOTANICAL LIBRARY AND ITS PUBLICATIONS.—The institution known as the Rachel McMasters Miller Hunt Botanical Library is the lengthened shadow of not only Rachel McMasters Miller Hunt but also of its director, George H. M. Lawrence. The history of the Library has been told well in *The Rachel McMasters Miller Hunt Botanical Library* (1961). The Library is a relatively new institution and has been housed in its present location in the penthouse of the Hunt Library on the campus of the Carnegie Institute of Technology in Pittsburgh since 1961. The setting and decor of the penthouse are truly beautiful and are a fitting place for the care and study of Mrs. Hunt's collection of incunabula, rare botanical and horticultural books, botanical prints, letters, manuscripts, and fine bindings.

Mrs. Hunt's interest in botany stemmed from her early girlhood—at the age of six she was given a copy of Mrs. Dana's *How to Know Wildflowers*. With the passing years as Mrs. Hunt acquired more and more rare works she realized that her collection was in many ways unique in North America. Her first steps toward sharing her collection with others resulted in the magnificent two volume *Catalogue of Botanical Books in the Collection of Rachel McMasters Miller Hunt* (1958, 1961). These two volumes deal with 764 works dating from about 1150 through 1800. The *Catalogue* was issued in a limited edition of 750 copies. Volume I was compiled by Jane Quinby, Mrs. Hunt's friend and librarian, and contains chapters by Harold W. Rickett, John F. Fulton, Paul B. Sears, Wilfrid Blunt, and Margaret B. Stillwell: Volume II, which is in two parts, was compiled by Allan Stevenson and contains introductory material prepared by Gordon Dunthorne, John S. Gilmour, and William T. Stearn. The volumes of the *Catalogue* are beautifully done with respect to printing, composition, paper, and binding.

In 1961 Mrs. Hunt's books were moved from the library at the Hunt's residence in Pittsburgh, Elmhurst, to the newly completed Hunt Library. The previous year, Dr. Lawrence had been appointed Director of the Hunt Botanical Library and since that time the Library has expanded its scope and activities to become a most important botanical research center.

The main activity of the Library at present is the *Bibliography Huntiana*, which may be characterized as a new Pritzel. When completed it will be a major bibliographical source in systematic botany, covering the literature from 1730 through 1840 and will comprise 16 quarto volumes. Title pages of books will be reproduced in facsimile. The preparation of *Bibliographia Huntiana* is being done, in keeping with the times, with the aid of computers.

The Library has already published two volumes of *Huntia*, *A Yearbook of Botanical and Horticultural Bibliography* (1964, 1965). *Huntia* contains an interesting series of papers by members of the Library staff and others. Of particular interest to western botanists is a paper entitled *Some Recollections of Percy Train*, by Chester A. Arnold (*Huntia* 2:111-116. 1965).

The collection of portraits of botanists, now numbering several thousand, is the special concern of Theodore W. Bossert. The collection is growing and in time should be the most complete in North America.

The Library has as another of its important functions the periodic exhibition of botanical illustrations. Notable among these have been the exhibition of Redoutéana during August, 1963. The catalogue of the exhibition, *A Catalogue of Redoutéana* (1963), follows the same high standards as the other Library publications.

Another function of the Library is periodic symposia. Those who attended the Adanson Symposium in 1963 will remember it with pleasure. The papers delivered by Jean-Paul Nicolas, Frans Stafleu, William Margadant, Mme. G. Duprat, Peter Sneath, and Théodore Monod were published in two parts entitled, *Adanson, The Bicentennial of Michel Adanson's "Familles des plantes"* (1963, 1965). *Adanson* is the first of the Hunt Monographic Series.

Additional collections in the Library consist of bookplates, examples of fine bindings, letters, and manuscripts. Eventually the Library will be a major depository for letters and thus an important source of material for those interested in historical aspects of botany.

Two works have so far been reproduced in the Hunt Facsimile Series. The first (1963) was L'Héritier de Brutelle's *Sertum Anglicum*. It is indeed a rare book in that only 35 complete copies of the original are known. The book is beautifully executed and includes introductory chapters by Frans Stafleu, John S. Gilmour, C. J. King, L. H. J. Williams, and Wilfrid Blunt. The second (1966) in the Facsimile Series is Walafrid Strabo's *Hortulus* or "The Little Garden." The *Hortulus* is of less interest to professional botanists than *Sertum Anglicum* as it predates Linnean nomenclature by nearly a thousand years. The *Hortulus* was reproduced because "Of all the gardening literature of this and ages past, nothing has survived longer, and little has been extolled more . . . It has survived this long, and should live for more than as long again, not because of gardening innovations, accounts of new plants, or pharmacological discoveries reported in it, but because it is beautiful poetry, because it is full of man's love for the earth and for the plants he grows in it." (forward, p. v).

Perhaps one of the most interesting aspects of the *Hortulus* facsimile is the series of prints by Henry Evans of San Francisco. Twenty-eight of his prints are used to decorate the English translation done by Raef Payne. Henry Evans is certainly among the foremost of contemporary botanical print makers and this is confirmed by the use of specially commissioned prints in the *Hortulus*.

Long before Mr. Evans started making botanical prints he was well known in San Francisco as a bookman, as a printer, and as the proprietor of the Peregrin Press. His botanical prints are not scientific illustrations in the sense of those that dot our technical floras and manuals, but are designed to give an impression of a



FIG. 1. Reproduction of a print of *Scoliopus bigelovii* Torrey, California Fetid Adder's Tongue, made by Henry Evans and reproduced by permission.

particular plant. He is interested in making botanical prints for decorative purposes. Whereas a scientific illustration puts in as many details as possible, Mr. Evans' prints avoid many details to achieve a clear, clean representation. His prints have an open, graceful, and airy character. There is no doubt, however, about their identity, as the reproduction (fig. 1) of *Scoliopus bigelovii* Torrey or California Fetid Adder's Tongue will demonstrate.

All of Mr. Evans' plants are drawn in their natural settings. He believes that the best composition exists in nature and that it should not be tampered with. For him printing is work and as he is more interested in finding a plant, drawing it, and cutting the linoleum block, he limits the number of prints from any one block to 100 and many to less than that number.

A complete set of Henry Evans' prints are among the recent acquisitions of the Hunt Botanical Library and an exhibit of his prints will be held at the Library in November of this year.



The Hunt Botanical Library is a specialized institution performing scholarly functions with both efficiency and taste. As our libraries become more and more crowded we will have to rely increasingly on specialized libraries, for much as we may hate to contemplate the notion, many libraries will not be able to house material as they have been accustomed to in the past. For this purpose, the Hunt Botanical Library serves as an admirable model. It deserves the full support of the botanical community and we should be grateful to its sponsors, director, and staff for their efforts.—JOHN H. THOMAS, Dudley Herbarium, Stanford University.

*The Origin of Cultivated Plants.* By FRANZ SCHWANITZ. pp. 175. Harvard University Press, Cambridge. 1966. \$4.75.

There is urgent need for a modern treatment of the origin of cultivated plants, patterned after De Candolle's classical work, "The origin of cultivated plants" published in 1886. In spite of the title, Schwanitz' little book of 175 pages evidently was never intended to fulfill this need. Indeed, the accumulated knowledge of the origin of cultivated plants is now so voluminous that it could not be compressed within the covers of a single volume of reasonable length. Furthermore, it is probably beyond the ability or capacity of one individual to treat the subject adequately.

Schwanitz' book was first published in 1955. The present version was translated from German by Gerd von Wahlert and published by Harvard University Press in 1966. Unfortunately, there is no indication that the opportunity for up-dating the text was used to advantage. As a result statements about corn, wheat and perhaps others do not reflect new and significant information about these crops.

The audience for which the book was prepared is not indicated, but it would be useful as supplemental reading for advanced undergraduate and graduate courses in economic botany, origin of cultivated plants, and other courses of like nature. Scientists or laymen whose work is with cultivated crops should find much of interest in the text.

A large portion of the book is devoted to specific examples of the ways in which wild plants differ from their corresponding cultivated forms. This is the most interesting and useful part of the book. Also, the well-known story of the transition of lupine from an essentially wild plant to a cultivated one under the skillful guidance of the German plant breeders, von Sengbusch and his colleagues, is reviewed in detail. The concluding chapter is a good short sketch of some of the highlights in the history of plant breeding.

The unwary reader should be cautioned against some rather serious errors that have crept into the text, most likely as the result of faulty translation. For example on page 5, Correns, de Vries and Tschermak are credited with the "discovery" of the laws of heredity. Obviously it should have been "rediscovery." This error is partially corrected on page 161 (156 pages later) with the statement: "The 'rediscovery' of Mendel's laws of heredity around the turn of the century, etc." On page 7, it is stated that wild rice, *Zizania aquatica* "was one of the most important food-stuffs of North American Indians." True, it was an important food for a few tribes in northern Minnesota where conditions are suitable for its culture. But to imply its use was wide-spread among North American Indians is completely misleading.

I doubt that those familiar with the taxonomy and systematics of maize would agree with the statement on page 146, "Maize, *Zea mays* is closely related to millet." Since this is an undocumented assertion it is difficult to guess what millet the author or the translator had in mind. These are samples of the errors that could be corrected should the popularity of the book call for a reprinting or a new edition.

It is apparent that the translator is not at home with agricultural terms and practices. Unfamiliarity has led to a number of awkward statements and phrases, and several redundancies. Under Literature about 20 general works are cited, none more recent than 1955. An index of about  $4\frac{1}{4}$  pages, with a few minor errors, completes the book.—THOMAS W. WHITAKER, United States Department of Agriculture, Agricultural Research Service, La Jolla, California.

*The California Deserts.* By EDMUND C. JAEGER. xii + 208 pp. Stanford University Press, 4th edition, 1965. \$4.95.

E. C. Jaeger's new edition of *The California Deserts* illuminates for the reader only a limited portion of the vast phenomena which occur in this extensive area of southeastern California. The book is primarily intended as a guide whose purpose is to acquaint the amateur naturalist or traveler with the general array of life in this region. It fulfills this function admirably as it includes chapters on history, climate, physiography, travel, preservation, and nearly all biological groups found in the desert including insects, fish, amphibians, reptiles, birds, mammals, aborigines, fungi, lichens, ferns, and higher vascular plants. However, the elucidation of each species is very short, which, as the author states has "... left it for the reader to detect where the nuggets lie ensconced." The new edition is essentially similar to the third except for several new photographs and the addition of chapters on aborigines and desert conservation.

Dr. Jaeger captures the very essence of the region with 16 magnificent plates and the simple statement that "... incoming rain clouds are generally for me the signal to start desertward. Let me have the delicious odors of the creosote bush and saltbush when they are wetted with gentle rains, look upon the endless variety and beauty of the clouds' far-flung forms, have the silence of the uninhabited mesas, and I am in a land enchanted."

For a person not acquainted with the desert this book offers an opportunity to learn some of the interesting salient features about the more common plant and animal inhabitants. The descriptions and drawings of the organisms, although sufficient for the uninitiated, are for the most part inadequate to provide exact identification. At times these become more of a check-list of species and their habitats leaving the reader with a crying desire for more information. Dr. Jaeger also describes many marvelous adaptations for survival in a desert environment and endows the reader with an appreciation for the country and its inhabitants.

Unfortunately, the desert region is rapidly being depleted as the heavily populated areas of California expand. Dr. Jaeger cites several examples of this encroachment and states: "Most unfortunate it is that, perhaps more than any portion of our land heritage, our deserts are thought by many as the most expendable lands we possess, mere wastelands that should if possible be utilized for gain. Even for many 'conservationists', conservation means only efficient exploitation of the land, getting everything possible out of it while perpetuating enough of what is left to serve as 'seed' for successive exploitations. . . . They would completely make over nature, leaving the 'man-did-it-look' upon almost every part of it."

Dr. Jaeger has combined his sensitive appreciation for the desert with his vast knowledge and has produced a well-written, pleasant book, which will be enjoyable reading for anyone interested in this region.—ROBERT M. LLOYD, Department of Botany, University of California, Berkeley.

## NOTES AND NEWS

NOTES ON SOME GRASSES OF THE PACIFIC COAST. — *Brachypodium sylvaticum* (Huds.) Beauv. was discovered growing in large colonies and apparently thoroughly naturalized at two localities in Benton Co., Oregon. This common woodland grass of Europe, Asia, and North Africa has been mentioned as introduced into North America for cultivation in ornamental grass gardens (Hitchcock, *Man. Grasses U. S.*, ed. 2, 57, 1950; Weintraub, *U. S. Dept. Agri. Handb.* 58:16. 1953). However, it has not previously been reported as well established in nature, at least on the Pacific Coast. At the Benton Co. sites, it grows in partial shade at the edges of woods, associated mainly with *Acer macrophyllum* and *Quercus garryana*. The following collections will be deposited at the Oregon State University herbarium (OSC): John Mellott

14, slopes E of Oak Creek, southern border of McDonald State Forest, R. 5 W., T. 11 S., Section 20; *K. L. Chambers* 2478, 3 miles W of the Willamette River bridge at Albany, R. 4 W., T. 11 S., Section 3. An earlier Oregon collection (OSC) of this species was submitted in December, 1939, by O. S. Fletcher, the locality given as "near Eugene," but without further habitat data. This grass probably is more common in the Willamette Valley than these few collections would indicate and has simply been overlooked. Although tall and gregarious, it could easily be mistaken for *Agropyron*, a genus whose inflorescence is quite similar to that of *Brachypodium*.

*Agrostis californica* Trin. is the name given in current manuals for a low-growing, dense-panicled coastal species which ranges from Monterey County, California, to about Lincoln County, Oregon, and which represents an element of the widespread and variable *A. exarata*-complex. In his early monograph of *Agrostis* (*U. S. Dept. Agr., Bur. Pl. Indus. Bull.* 68:30. 1905), Hitchcock referred this plant to *A. glomerata* (Presl) Kunth, based on *Vilfa glomerata* Presl (*Rel. Haenk.* 1:239. 1830), whose type locality is "in montanis Peruviae huanoccensibus." In subsequent publications Hitchcock segregated the North American material as *A. californica* Trin., described in 1841. However, the bibliographical citation given in the Hitchcock (*op. cit.*, 804) leads one to suspect that this name may be illegitimate. It states that in the description of *A. californica*, *Vilfa glomerata* Presl was "erroneously cited as synonym." I have examined a reprint of the original publication by Trinius, from the Hitchcock and Chase agrostology library at the U. S. National Herbarium. It is titled "Agrostidea," and is a separate from the Memoires of the Royal Academy of St. Petersburg bearing somewhat different pagination (according to Hitchcock's notes). Following his Latin description of *A. californica*, Trinius gives the citation, "*Vilfa glomerata* Presl! *Rel. Haenk. fasc. IV, p. 239. California. In montanis Peruviae huanoccensibus.*" Through this reference to an earlier available epithet, the name as published is superfluous, and under the present rules of nomenclature it must be rejected. The correct name for this plant, assuming it is not conspecific with *A. glomerata* of Peru, is *A. densiflora* Vasey (*Contr. U. S. Natl. Herb.* 3:72. 1892). The type specimen is from Santa Cruz, California.

*Agrostis alaskana* Hultén, found in coastal Alaska and the Aleutian Islands, is a member of the species group that includes *A. scabra* Willd. and *A. borealis* Hartm. Hultén proposed the name (*Fl. Aleut. Isl.*, ed. 1, 71, 1937) as a substitute for *A. aenea* (Trin.) Trin., an illegitimate homonym. However, Hitchcock, in his 1905 monograph of *Agrostis* (*op. cit.*, 51) had published the name *A. melaleuca* (Trin.) Hitchc. for this plant, and a reference to this is cited by Hultén in his synonymy of *A. alaskana*. Hultén argued that *A. melaleuca* could not be used because it was based on *A. canina* var. *melaleuca* Trin., which was described from two specimens representing different species (as was admitted later by Trinius, and by Hitchcock). It is clear from Hitchcock's publication, however, that *A. melaleuca* is a legitimate name; it is an avowed new combination of the epithet *melaleuca* of Trinius, and Hitchcock specifies as a lectotype the specimen he believes is conspecific with *A. aenea*, excluding the second specimen (which was probably a plant of *A. aequivalvis*, a very different species). It must be admitted that Hitchcock made the lectotypification by inference from the description, since on his visit to the Trinius herbarium at St. Petersburg he could not locate the type specimen of *A. canina* var. *melaleuca*. Nonetheless, he did not, as Hultén believed, base the name *A. melaleuca* on the type specimen of *A. canina* var. *aenea*; he merely stated that he saw the latter type at St. Petersburg. I conclude, therefore, that *A. alaskana* Hult. is superfluous and illegitimate, and the name *A. melaleuca* (Trin.) Hitchc. should be used if this plant is considered a distinct species. It is worthwhile to note that Hitchcock's own later disposition of this taxon (*Fl. N. Am.* 17:530. 1937) was as a strict synonym of *A. borealis*. The status of these taxa in Alaska very much needs clarification.

Thanks are extended to LaRea D. Johnston and Curt G. Carlbom for their help in the preparation of these notes. — KENTON L. CHAMBERS, Department of Botany, Oregon State University, Corvallis.



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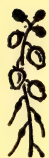
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# MADROÑO

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A REVISION OF PETALONYX (LOASACEAE) WITH  
A CONSIDERATION OF AFFINITIES IN  
SUBFAMILY GRONOVIOIDEAE

WILLIAM S. DAVIS and HENRY J. THOMPSON

*Petalonyx* is a genus of shrubs and sub-shrubs of the desert and semi-arid regions of the southwestern United States and Northern Mexico. Although a few modern floras give good accounts of some of the species, no monograph treating the entire genus has been prepared. Apparently *Petalonyx* has not invited the attention of monographers because the species are relatively distinct and hence new collections are not difficult to identify. Nevertheless, it is remarkable that taxonomists have been content merely to describe the flowers of *Petalonyx* as having the stamens located outside the corolla tube without attempting to understand such unorthodox morphology. Our attention was first drawn to *Petalonyx* during the general survey of the family to determine generic limits preparatory to a more detailed study of *Mentzelia*. Although we encountered no difficulty in delimiting *Mentzelia* from *Petalonyx* we did raise some questions concerning the generic affinities of *Petalonyx* with the other members of subfam. Gronovioideae. In addition to the five species of *Petalonyx*, subfam. Gronovioideae accommodates the one species of *Cevallia*, the two species of *Gronovia*, and the one species of *Fuertesia* (Urban and Gilg, 1900). Although our interest has been centered on *Petalonyx* we have extended our observations to the other genera of this subfamily whenever possible.

Four of the five species of *Petalonyx* have been studied as living plants in natural populations and only *P. crenatus* of north central Mexico remains unknown to us as living material. *Cevallia* has been studied in two natural populations and one species of *Gronovia* has been grown in our greenhouse. Thus we have had living material of six of the nine species of subfam. Gronovioideae, making cytological and anatomical studies possible. Chromosomes were examined by fixing anthers in 3:1 ethanol-acetic acid, squashing in acetocarmine, and observing with a phase microscope. Anatomical studies were made from material either embedded in paraffin and sectioned or simply cleared in lactic acid. Voucher specimens for our chromosome number determinations are on file in the herbarium of the University of California, Los Angeles (LA). We have examined all the specimens of *Petalonyx* from the following herbaria: BAYLU, DAS, DS, GH, LA, LL, POM, RSA, SMU, TAES, TEX, US. The manuscript benefited greatly from the critical comments of Peter H. Raven and Wallace R. Ernst. This study was supported by Grant GB-1337 from the National Science Foundation.

## PETALONYX

Some of the features of *Petalonyx* are of particular interest and will be singled out here for detailed consideration while a later section of this paper will present a formal taxonomic treatment with descriptions and keys. The flowers of the five species are borne in naked or bracted racemes and are generally similar in their inferior, unilocular ovary with a single, pendulous ovule. No matrix tissue proliferates in the lumen between the developing seed and the ovary wall and there is no disc at the apex of the ovary. The fruit is indehiscent and the mature seed is pyriform, lacks endosperm, and has a smooth to finely striated testa. The cotyledons are ovate and the inner surfaces are smooth. The simple style and stigma and the calyx, which is deeply divided into five lanceolate lobes, also are quite uniform throughout the genus. In contrast, the petals and stamens exhibit some unusual features that distinguish some of the species. *Petalonyx nitidus*, *P. thurberi*, and *P. parryi* are distinctive by their apparently sympetalous corollas with the anthers outside the corolla tube (fig. 1). *Petalonyx crenatus* is unique in having only two functional stamens and the flower is thus bilaterally symmetrical (fig. 1). *Petalonyx linearis* remains distinct by its orthodoxy for it lacks these unusual characters. Certain morphological features, whose modifications provide these unusual floral differences, are present throughout the genus. The petals in all species are clawed and each side of the claw has two narrow flaps of tissue, one inner and one outer, that extend laterally toward the adjacent petals (fig. 2e). The stamens are not in themselves unusual, being composed of a slender filament with a terminal, 4-chambered anther, however the filaments arise from the short hypanthium opposite the sepals and between, but apparently in the same whorl with, the petals (fig. 2a). In bud the low portions of the filaments are held between the inner and outer flaps of adjacent petal claws (fig. 2b-f) while the distal portion of the filaments and the anthers are enclosed by the petal limbs (fig. 2g). In *P. thurberi*, *P. nitidus*, and *P. parryi* the inner flaps of tissue of adjacent petals remain free near the base (fig. 2b) but become firmly connivent along the upper half of the claw thus forming a corolla tube (fig. 2c-e). As the buds open, the staminal filaments are freed to incline outward while the petals remain held together—hence the unusual condition of the stamens outside the corolla tube. Although the claws become strongly connivent and sometimes can be pulled apart only by tearing tissue, it is clear that they are secondarily adhered together because the cuticle that covers the epidermis is continuous through the point of connection of adjacent claws. Although the petal claws in *P. linearis* and *P. crenatus* have the flaps of tissue, they do not become connivent in these species, no tube is formed, and the stamens are not held outside of the corolla.

The cross sections of the flowers also revealed a difference in the vascularization of the style. In *P. thurberi*, *P. nitidus*, and *P. parryi*



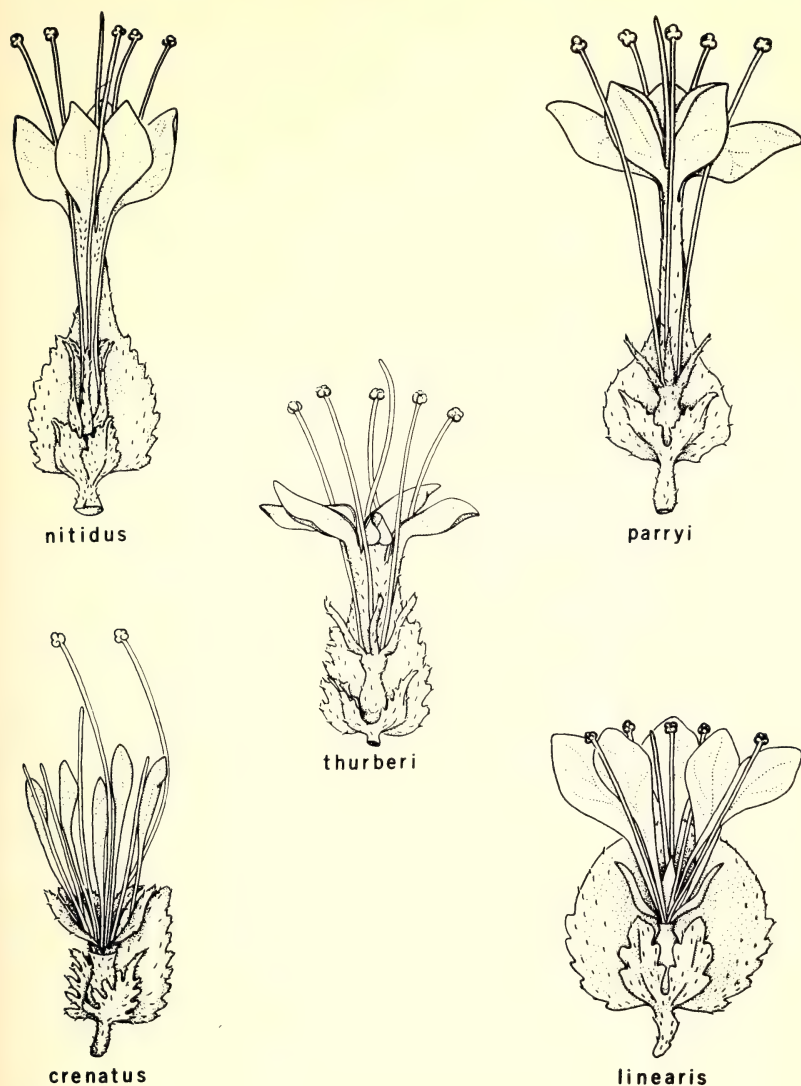


FIG. 1. Drawings of flowers and bractlets of the five species of *Petalonyx*. The petals in *P. nitidus* are just opening, all others with petals fully expanded, 4 $\times$ .

there are three vascular traces while in *P. linearis* and *P. crenatus* there are only two. These differences were noted in the examination of about 15 flowers of the five species with only one flower of *P. parryi* being anomolous in having four traces in the style.

Plants of the five species of *Petalonyx* are perennial but the growth form characteristic of each species ranges from woody only at the very base, as in *P. thurberi*, to a well developed but small shrub, as in

*P. parryi*. The leaves are simple but have a number of consistent differences of shape and margin, which distinguish the species.

Like most members of the Loasaceae, the plants of *Petalonyx* are covered with a harsh pubescence. *Petalonyx* has a type of trichome that also is found in all plants of the family, but unlike many genera, *Petalonyx* only has this "basic" type (fig. 6a, b). These trichomes are found in somewhat modified forms on different parts of the same individual and all of the taxa can be recognized by at least slight differences in the pubescence. *Petalonyx linearis* is most distinct in its pubescence in having short, truncate trichomes on the stems which contrast sharply with the long slender trichomes of the bracts and ovary. The pubescence of *P. parryi* and *P. nitidus* is quite similar but the stem pubescence in *P. parryi* is straight while in *P. nitidus* it is reflexed. The two subspecies of *P. thurberi* are distinguished primarily by a difference in pubescence with ssp. *gilmanii* having a finer, longer, and more dense pubescence than ssp. *thurberi*.

Meiosis has been observed in plants from six populations representing four of the five species of *Petalonyx*, including both ssp. of *P. thurberi*, with only *P. crenatus* remaining unknown chromosomally. All of the plants examined showed 23 pairs of chromosomes. Metaphase bivalents are approximately 3 micra long although in every cell examined there were slight but obvious differences in the size of the bivalents so that a continuous series from smaller to larger bivalents could be noted. Chromosome observations of *Petalonyx*, were made on the following collections: *P. linearis*,  $n = 23$ , N of San Felipe, Baja California, Mexico, Raven 14791; *P. nitidus*,  $n = 23$ , Panamint Springs, Inyo Co., California, Thompson 3273; *P. parryi*,  $n = 23$ , near Glendale, Clark Co., Nevada, Thompson 3274; *P. thurberi* ssp. *thurberi*,  $n = 23$ , 10 miles W of Kingman, Mohave Co., Arizona, Thompson 3294; 9 miles W of Randsberg, Kern Co., California, Kyhos, May 12, 1962; *P. thurberi* ssp. *gilmanii*,  $n = 23$ , Ryan Wash, Death Valley National Monument, California, Davis 170.

Information about the breeding system in *Petalonyx* is limited to that suggested by flower structure and seed set in natural populations. In *P. linearis* the stigma is located among the anthers at the time pollen is shed (fig. 1) and self-pollination in each flower seems inescapable. In the other four species the anthers are positioned well away from the stigma when the pollen is shed (fig. 1) and some vector must be necessary for pollination. In the herbarium specimens of *P. linearis* over 90 percent of the ovaries contain a seed while in the other four species seed set frequently is about 50 percent. This information, together with the floral morphology, suggests that *P. linearis* is highly self-pollinated, self-compatible, and hence an inbreeding species while the other four species are more highly outbreeding. Timberlake (1962, pp. 14, 36-38) suggests that the bees *Perdita exilis* Timberlake and *P. crandalli* Timberlake probably are oligolectic on *Petalonyx thurberi*

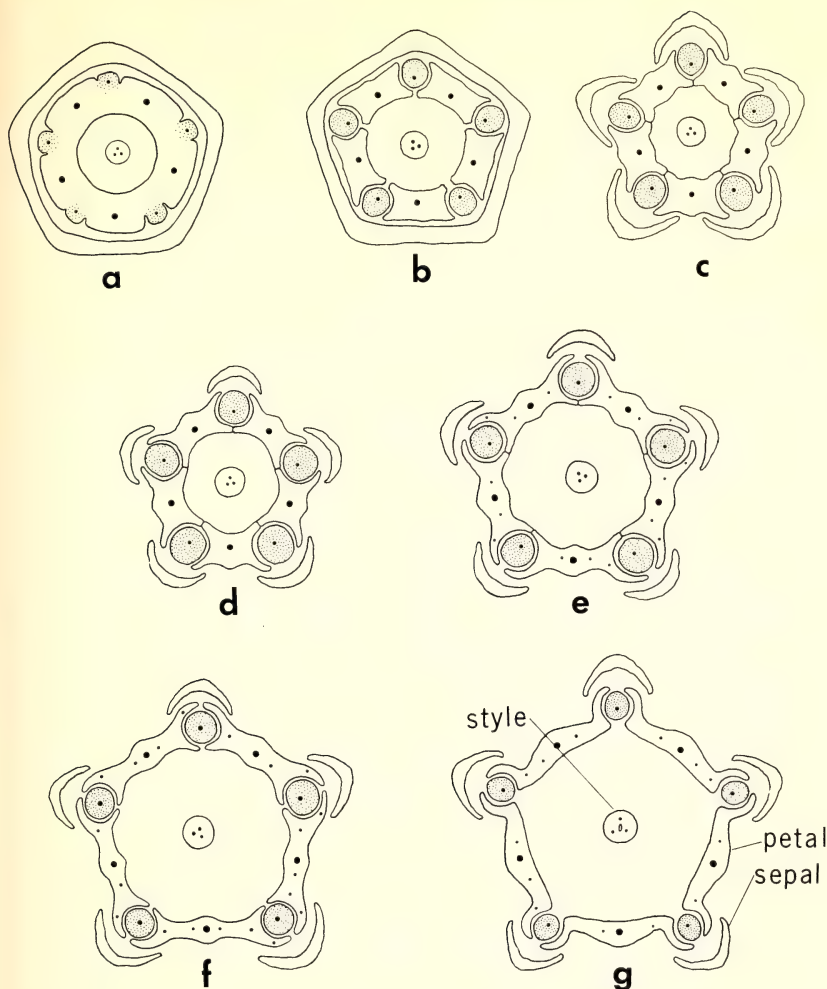


FIG. 2. Transverse sections through a flower of *Petalonyx thurberi* before anthesis (filaments stippled): a, section through the calyx tube and upper portion of the ovary; b, section through an area just above (a); c, section through the calyx lobes, petal claws, and style; d, section through an area above (c); e, section through an area above (d); f, section through an area above (e); g, section through an area above (f) showing the calyx lobes, petal limbs, filaments, and style.

and they may be important pollinators. The flowers of *P. thurberi*, *P. nitidus*, and *P. parryi* are lightly fragrant and attract a variety of insects, many of which could effect pollination.

Although all five species of *Petalonyx* are restricted to the arid regions of the southwestern United States and northern Mexico we have been unable to find two species growing in mixed or adjacent populations. This is because of the very limited ranges of two of the

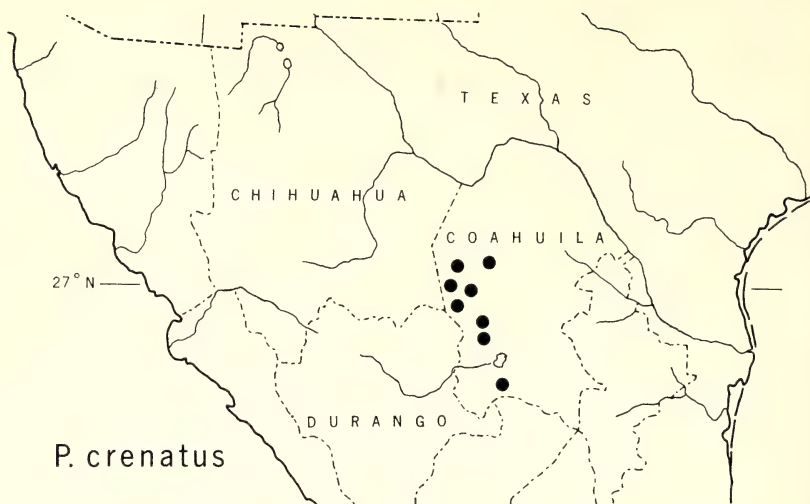
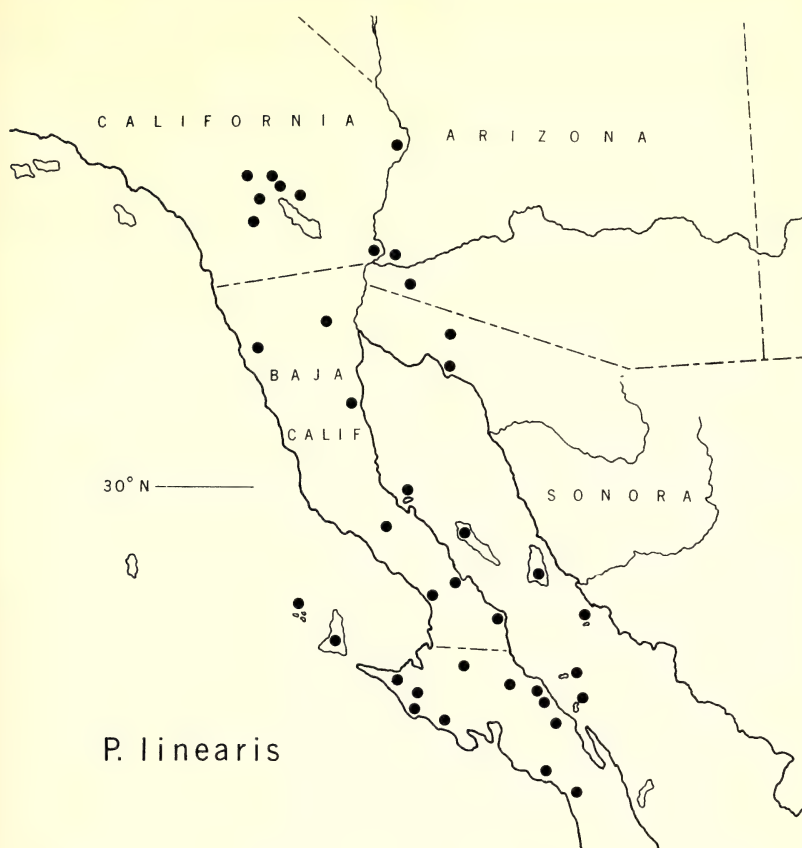


FIG. 3. Distribution of *Petalonyx crenatus*.

species, their different ecological requirements, and the small size of local populations. *Petalonyx crenatus*, morphologically very distinct with its slightly irregular flowers, narrow petals, and distinctive crenate leaves also is geographically isolated, growing only in western Coahuila, Mexico, where it is disjunct by 500 miles from the other species of the genus (fig. 3). *Petalonyx linearis*, also morphologically very distinct, occurs in sandy areas of the lower Colorado Valley and Vizcaíño regions of the Sonoran Desert (fig. 4) usually below 2500 feet elevation. The autogamous breeding habit and restriction to the geologically new desert habitats suggest a derivative status for *P. linearis*. *Petalonyx thurberi* also ranges into the Sonoran Desert and seems so similar to *P. linearis* in habitat preference that we are forced to ascribe our inability to find them growing together merely to chance. *Petalonyx thurberi*, *P. nitidus*, and *P. parryi* are not only morphologically similar to each other but they occur in the same general area (fig. 5). *Petalonyx thurberi* occurs in sandy areas and washes of the Mojave Desert and extends into the upper regions of the Sonoran Desert. It usually occurs at elevations between 1000 and 3000 feet although stations above and below these limits are not exceptional. *Petalonyx thurberi* ssp. *gilmanii* is restricted to the Death Valley region. *Petalonyx nitidus* occurs on more rocky soils in the Mojave Desert, usually above 3000 feet elevation and extending as high as 7000 feet. Where *P. thurberi* and *P. nitidus* occur in the same area we have found *P. nitidus* at higher elevations than *P. thurberi*. *Petalonyx parryi* is restricted to a local area near the Virgin and Colorado rivers in southern Nevada and adjacent Utah and Arizona (fig. 5). It is found at elevations below 3000 feet and is probably restricted to white to grey clay soils.



FIG. 4. Distribution of *Petalonyx linearis*.

The species of *Petalonyx* obviously are similar in many respects and the differences between them can be understood as variations on a basic theme. The question of which other group of populations in the Loasaceae is most similar to *Petalonyx* is not so readily answered. Similarity to *Cevallia*, *Gronovia*, and *Fuertesia* is suggested by the grouping of these genera with *Petalonyx* to form subfam. Gronovioideae on the basis of the single, pendulous ovule and the reduced number of stamens common to all four genera.

#### CEVALLIA

The single species of this genus, *C. sinuata* Lag., occurs in northern and eastern Mexico and the southwestern United States. The plants are low herbaceous perennials with only the basal stems becoming woody. The leaves are sinuate-pinnatifid and, like all members of Loasaceae, the plants are covered with a harsh pubescence. There are three different types of trichomes, all one-celled, which may occur side by side on a single organ. Some of the trichomes are like the basic type found

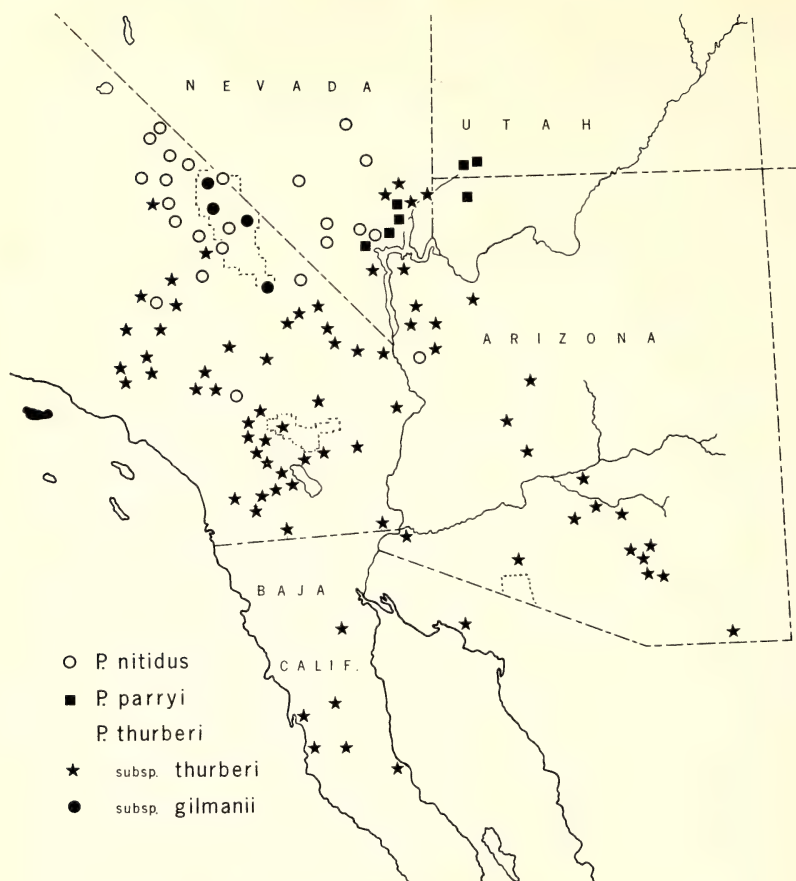


FIG. 5. Distribution of *Petalonyx nitidus*, *P. parryi*, and *P. thurberi*.

in *Petalonyx* and throughout Loasaceae (fig. 6a, b). A second trichome type is dendritic, 0.1 mm long, and forms a dense tomentum over much of the plant (fig. 6f). A third trichome type is up to 3 mm long, straight, without barbs but with a very acute apex (fig. 6e). The base of these trichomes is buttressed by a ring of numerous columnar epidermal cells. These trichomes probably are the ones that so readily penetrate human skin and account for the painful, stinging sensation when the plant is touched. The first two types of trichomes lack the basal, columnar cells that surround the base of the long trichome.

The flowers are clustered in tight heads at the ends of peduncles that are borne opposite the leaves. The ovary is inferior and produces one, pendulous seed that lacks endosperm. The cotyledons are ovate and smooth on the inner surface. The fruit is indehiscent with the sepals and petals persistent. There is no matrix tissue that develops about the

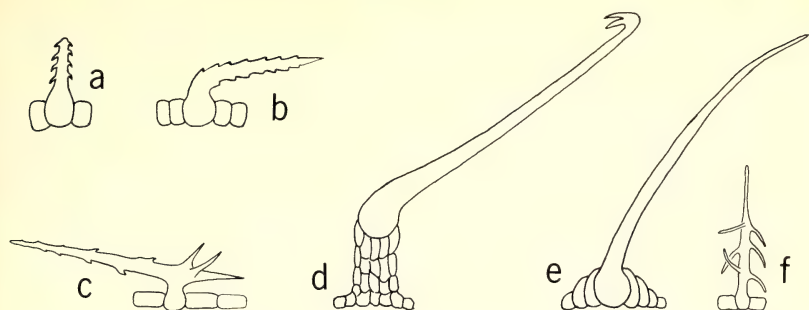


FIG. 6. Diagrams of longitudinal sections of trichomes in subfam. Gronovioideae: a, b, *Petalonyx*, 50 $\times$ ; c, *Fuertesia*, 20 $\times$ ; d, *Gronovia*, 20 $\times$ ; e, *Cevallia*, 20 $\times$ ; f, *Cevallia*, 15 $\times$ .

ovule as in *Gronovia*. Atop the ovary is a short hypanthium from the outer edge of which arise ten similar segments, but there is no disc within the hypanthium. The five segments opposite the stamens usually are considered calyx-lobes while the other five are considered petals. Both series are erect, linear, very pubescent, and plumose by virtue of the long trichomes along the margins. When the flower opens and pollen is shed the petals are held inward about the stamens while the sepals are turned slightly outward. Both petals and sepals are yellow on the inner surface but the petals are somewhat brighter in color and are slightly less plumose. The five stamens arise from the top of the hypanthium with short, thick filaments and the anther is borne on the adaxial surface of the filament with the basal portion of the anther free. The connective extends well beyond the anther as a hollow, thin-walled, somewhat inflated appendage. The style is short and topped by a conical stigma that is positioned opposite the base of the anthers. Meiotic chromosomes have been observed in two plants from two different populations and each had 13 pairs of chromosomes. The chromosomes are all the same size and the metaphase bivalents are nearly five micra long. Chromosome observations of *Cevallia* were made on the following collections: *C. sinuata*,  $n = 13$ , 14 miles S of Mammoth, Pinal Co., Arizona, *Thompson 3221*; 33 miles N of Van Horn, Culbertson Co., Texas, *Thompson 3286*. In the Van Horn population the flowers were noted to have a faint fragrance and were visited by a great variety of insects, particularly bees and butterflies. Flower structure makes self-pollination inevitable but outcrossing might still obtain if the plants are self-incompatible.

#### GRONOVIA

The two species of this genus, *G. scandens* L. and *G. grandiflora* Urban & Gilg, are readily distinguished by differences in the size and proportions of the flowers but otherwise are so similar that for our purpose of characterizing the genus we need not distinguish between

them. *Gronovia* occurs throughout much of Tropical America from Venezuela and Ecuador to northern Mexico. The plants are herbaceous perennial vines with long petioled, simple leaves. The blades are broadly ovate with cordate bases and coarsely toothed, often 3–5 lobed margins. In addition to having the typical trichomes found throughout Loasaceae, (fig. 6a, b) the plants have a very characteristic trichome type that is about 3 mm long and is unarmed except that the apex is formed into a double hook (fig. 6d). These hairs are supported by a mass of columnar cells that surround the basal portion of the trichome cell and raise the base of this cell well above the level of the plane of the epidermis. This type of trichome occurs only on the stems and the adjoining portion of the petioles. The inflorescence is open and borne on peduncles that are opposite the leaves. The ovary is inferior, is topped by a disc with a crenate margin, and has one pendulous ovule. The single ovule is surrounded by a matrix of spongy tissue which is compacted as the seed enlarges and fills the ovary cavity after the seed is formed. The fruit develops five prominent, longitudinal ridges and is indehiscent. The seed lacks endosperm and the seed coat is membranous and unornamented. The cotyledons are ovate and their inner surfaces are strongly rugose. The ovary is topped by a short hypanthium from the rim of which extend five calyx-lobes. The petals are free, narrow, and rather inconspicuous. The stamens have slender filaments and a terminal, 4-celled anther. The style is slender and has a small, capitate stigma that is situated among the anthers. Meiotic chromosomes of one plant of *Gronovia scandens* have been examined. The 37 pairs of chromosomes were of equal size and somewhat smaller than those of *Cevallia* but larger than the chromosomes of *Petalonyx*. Chromosome observations were made from the following collection: *G. scandens*,  $n = 37$ , cultivated strain grown from seed obtained from the Botanical Garden, Copenhagen, culture number at Los Angeles, *Thompson 3234*. A mitotic chromosome count of  $2n = 76$  was reported by Hamel (1938) for *G. scandens* growing in the Jardin des Plantes at Paris. We have readily cultured *G. scandens* in our greenhouse. The position of the anthers and stigma insure self-pollination and the formation of many viable seeds on the plants cultured in our greenhouse indicates that the plants are self-compatible.

#### FUERTESIA

This genus contains a single species, *F. domingensis* Urban, which is restricted to the island of Hispaniola in the West Indies. It differs from *Gronovia* in having lobed petals, an entire margined disc on the apex of the ovary, and a simple stigma, but in general appearance it is like *Gronovia*. The pubescence of *Fuertesia* consists of two different types of trichomes in addition to the basic type found in other genera of Loasaceae. The first type is like the double-hooked trichome found on the stem and basal portions of the petioles of *Gronovia* (fig. 6d) but



is shorter with a few barbs along its length. The second type of trichome is unique to *Fuertesia* and has been found only on the leaves (fig. 6c).

#### SUBFAMILY GRONOVIOIDEAE

Although our considerations of *Cevallia*, *Gronovia*, and *Fuertesia* were only peripheral to our monograph of *Petalonyx*, we feel some authority to comment on the affinities of these genera within the Loasaceae.

*Gronovia* and *Fuertesia* obviously are more similar to each other than to any other genera. They have similar forms, similar floral morphology, and share the unique bifid trichome which occurs nowhere else in the family. Although these two genera may be considered closely related, no such comparable relationship is indicated among the other genera. *Petalonyx*, *Cevallia*, and *Gronovia* were grouped by Urban and Gilg. in subfam. Gronovioideae by giving great weight to two characters: stamens 5 in number and ovary with a single seed. Emphasis of these two characters gives a distorted representation of the affinities among these genera. For example, while *Petalonyx* and *Cevallia* are similar in having 5 stamens, and thus are unlike all species of subfam. Mentzelioideae and subfam. Loasoideae, a different view is reached when the individual stamens are compared. In stamen morphology *Petalonyx* and *Cevallia* are more different from each other than either of these two genera are from any other genera in the family. Similar evaluations may be made about the number of seeds per capsule. Several species (e.g., *Mentzelia oligosperma*, *Fissenia* sp.) have the seeds reduced to 1-3 per capsule. Reduction in seed number occurs in conjunction with indehiscent capsules and small flowers in many otherwise distinct groups in Loasaceae. Furthermore, the information from chromosome numbers does not indicate any relationships among any of the genera currently grouped in subfam. Gronovioideae.

We consider *Petalonyx*, *Cevallia*, and the *Gronovia-Fuertesia* alliance, which now comprise subfam. Gronovioideae, to be three divergent groups whose affinities lie with other genera in the family and not with each other. However, until a more thorough study is made of all of the genera in this family none of the details of these similarities can be recorded in a formal taxonomic form and we must be content merely to have pointed out the very artificial basis of subfam. Gronovioideae.

#### TAXONOMY OF PETALONYX

PETALONYX A. Gray, Mem. Am. Acad. 5:319. 1855. Shrubs or subshrubs; leaves alternate, petioled or sessile, entire, toothed or crenate; inflorescence a naked or bracted raceme, or spicate raceme; each flower involucrate with three green bractlets at the summit of the pedicel, two of which are smaller and lateral; sepals joined to form a tube adnate to the ovary, cleft almost to the base, the lobes linear to lance-linear, inner surface glabrous, outer hispid, persistent or irregularly deciduous; petals cream to white, clawed, inner surface glabrous, outer hispid;

claws free or connivent to form a tube; limbs usually reflexed; stamens free, originating between, and apparently in the same whorl as the petals, outside the petals at anthesis and in bud curving inside and covered by the overlapping petals; anthers 4-celled; pollen elliptic, tricolpate, unornamented; style filamentous; stigma simple; mature fruit a uniloculate utricle, cylindrical; constricted near the apex, then flaring above, 3-5 nerved, with brittle, usually ribbed walls; ovule 1, without endosperm, pendulous; seed pointed at the hilum, unornamented or with fine striations on the testa; embryo with thick, plano-convex cotyledons and a short, acute, radicle.

Type Species: *Petalonyx thurberi* A. Gray.

#### KEY TO THE SPECIES

Petal distinct.

Anther bearing stamens 2, about twice as long as the petals, sterile filaments 3, about as long as the petals; leaf margins revolutely crenate; bractlets oblong, truncate at the base; petal limb less than twice as wide as the claw; Coahuila, Mexico. . . . . *P. crenatus*

Anther bearing stamens 5, equaling the petals in length; leaf margins entire or remotely dentate; bractlets ovate, the base cordate; petal limbs at least twice as wide as the claw: deserts of California, western Arizona, Baja California, Sonora, and the Islands of the Gulf of California  
2. *P. linearis*

Petals connivent, the claws forming a tube.

Leaves sessile, reduced upward along the stems; petals shorter than 5 mm; widely distributed in the desert areas of southern California, Baja California and Arizona. . . . . 3. *P. thurberi*

Leaves petiolate, similar in size along the stems; petals longer than 5 mm.

Sub-shrubs, predominately herbaceous, current seasons growth longer than 10 cm; leaf margins coarsely few-toothed; inflorescence a bracted raceme; petals shorter than 11 mm; Inyo and San Bernardino of California to southern Nevada and northern Arizona above 3000 feet elevation. . . . . 4. *P. nitidus*

Shrubs, predominately woody, current seasons growth less than 10 cm long; leaf margins entire to crenate; inflorescence a naked, terminal raceme; petals longer than 11 mm; Coconino and Mohave counties of Arizona to southern Utah and Nevada, usually on white to grey clay soils and below 3000 feet elevation. . . . 5. *P. parryi*

1. *PETALONYX CRENATUS* A. Gray ex Watson, Proc. Am. Acad. 17:358. 1882. Suffrutescent, with short, erect, brittle, herbaceous branchlets, up to 10 dm high; stems of the current season 10-20 cm long, to 6 mm wide, surface smooth, grey-green or yellow-green, densely hispid with long, pointed, antrorsely barbed, retrorsely appressed hair; older stems straw-colored to dark grey; leaves sessile, similar in size along the stems, 0.6-1 cm long, 0.2-0.4 cm wide, oblong-lanceolate, obtuse, cordate, revolutely crenate, green, hispid with fine, long, antrorsely barbed hairs on both surfaces, and short, truncate retrorsely barbed hair along the margins; inflorescence a terminal, naked raceme, 20-40 flowered, to 5 cm long, elongated in fruit, the lower fruit fallen; pedicels

1.0–2.5 mm long; large bractlet 3–5 mm long, 1.5–2.5 mm wide, triangular-ovate to oblong with a prominent midrib before maturity, acute, truncate to sub-cordate, crenate basally, hispid with long, pointed, antrorsely barbed hair; lateral bractlets 2–3 mm long, 1.5–2 mm wide, ovate to triangular-ovate, pinnately cleft, hispid; sepal lobes 1.5–2.5 mm long, 0.5–0.9 mm wide, recurved, persistent; petals white, linear to narrowly spatulate, acute, claw not sharply delimited from the limb, 4–7 mm long, 1–1.5 mm wide, not connivent; claw 0.7–0.9 mm wide, with short, epidermal papillae; two fertile stamens, well exerted, 10–11 mm long, three sterile stamens 5–9 mm long; filaments with basal epidermal papillae; anthers 0.5–0.6 mm wide; pollen 24.7–28.2 micra in diameter; style 5–10 mm long, shorter than fertile stamens; mature fruit 1.5–2.5 mm long, 1.1–1.5 mm wide at the base, 0.8–1 mm wide at the apex, hispid with pointed or truncate, retrorsely barbed hair to 0.4 mm long; seed 1.8–2 mm long, 0.8–1 mm wide. Chromosome number unknown.

Type. San Lorenzo de Laguna, 75 miles SW of Parras, Coahuila, Mexico, *Palmer 833*, in May of 1880 (GH, isotype US).

Distribution (fig. 3). Sandy plains, gypsum mesas, and dry trough-like valleys, Coahuila, Mexico.

Specimens examined. MEXICO. COAHUILA: About 30 miles S of Sierra Mojada, *Wynd 769*; Sierra del Rey, *Purpus 4466*; W base of Picacho del Fuste, *Johnston 8353*; 16 miles S of Laguna del Rey, *Johnston 7808*; near Mohovano, *Shreve 8831*; between La Vibora and Matrimonia Viejo, *Johnston 9348*; Rancho Parritas, E margin of the Valle de Acatita, *Stewart 2762*; Las Delicias, *Stewart 2959*; W of El Oro, *White 2006*; S end of Cañada Oscuro near Tanque La Luz, *Johnston 8487*.

2. *PETALONYX LINEARIS* Greene, Bull. Calif. Acad. 1:188. 1885. Suffrutescent, almost globose with numerous erect branches, 1.5–10 dm high; current seasons growth 10–38 cm long, to 6 mm wide, grooved, grey-green to dull green, scabrous with short, tapered, truncate, retrorsely barbed hair, perpendicular to the stem; older stems white to grey; leaves sessile to very short petioled, similar in size along the stems, 1–4.2 cm long, 0.3–1.5 cm wide, linear to oblanceolate, acute or occasionally obtuse, narrowed basally becoming cuneate to obtuse, entire or rarely remotely dentate, green and somewhat shiny, muricate-hispid with long, pointed, antrorsely barbed hair on the abaxial surface and truncate, retrorsely barbed hair on the adaxial surface, and mixed truncate and pointed hair along the margins; inflorescence a short, capitate, terminal spike, 30–60 flowered, 4–10 cm long, elongated in fruit to 21 cm, the lower fruit fallen; pedicels 1–2 mm long; large bractlet 5–8 mm long, 5–6 mm wide, ovate to round-ovate, acute to obtuse or rarely retuse, cordate to deeply cordate, entire, sinuate or minutely crenulate at the base, hispid on both surfaces and the margins



with long, fine, pointed, antrorsely barbed hair; lateral bractlets 3–3.5 mm long, 2–2.2 mm wide, ovate, acute to obtuse, sub-cordate, lobed, hispid; sepal lobes 1–2 mm long, 0.7–0.8 mm wide, erect, irregularly deciduous; petals white, 2–5.5 mm long; claw 1.4–3.1 mm long, linear, with no epidermal papellae, few hairs, and not connivent; limb 1.7–2.4 mm long, 1.3–1.4 mm wide, ovate, acute, hispid; stamens barely exserted, 3–7 mm long; filaments without epidermal papillae; anthers 0.3–0.5 mm wide; pollen 24.2–28.2 micra in diameter; style 2.8–6 mm long, nearly equal in length to the stamens, without epidermal papillae; mature fruit 5 nerved, usually 3 ribbed, 2–4 mm long, 1.2–1.6 mm wide at the base and 0.5–0.6 mm wide at the apex, pubescent with dense, long, pointed, retrorsely barbed, antrorsely appressed, easily deciduous hair, to 0.7 mm long; seed 2.3–2.5 mm long, 0.9–1 mm wide. Chromosome number,  $n = 23$ .

Type. Cedros Island, common in the canyons of the middle of the island, on the E side, Baja California, Mexico, *Greene*, May 1, 1885 (CAS).

Distribution (fig. 4). Occasional in rocky places in canyons but common in sandy soil below 3,000 ft.; Lower Sonoran Zone, Creosote Bush Scrub, California to southwestern Arizona, southward to Baja California, Sonora and the islands of the Gulf of California.

Specimens examined. *Petalonyx linearis* is well represented in U.S. herbaria and over 100 collections have been annotated.

3. PETALONYX THURBERI A. Gray, Mem. Am. Acad. 5:319. 1855. Suffrutescent, often broader than tall, to 10 dm high; stems of the current season 12–45 cm long, to 6 mm wide, striate or smooth, grey-green, hispid; older stems white or yellowish; leaves sessile, reducing in size along the branches, 0.4–4.5 cm long, 0.2–1.4 cm wide, variable in shape, deltoid-ovate to lanceolate, acute to acuminate, cuneate to cordate-clasping, entire to few toothed (teeth 0.3–1.8 mm long and 0–4 on each margin), grey-green, dull to somewhat shiny, hispid to densely hispid with long pointed antrorsely barbed hair; inflorescence a short, dense, naked, terminal, spicate raceme, 10–40 flowered, 1–4 cm long, slightly elongated in fruit; pedicels 0.2–0.7 mm long; large bractlet 3.2–7.5 mm long, 2.1–5.9 mm wide, deltoid-ovate to triangular-ovate, acute to somewhat acuminate, obtuse to sub-cordate, entire or crenate at the base (0–8 teeth per margin), hispid with dense, antrorsely barbed, pointed hair; lateral bractlets 2–3 mm long, 0.8–1.4 mm wide, lanceolate to ovate, unequally crenate to lobed, hispid; sepal lobes 1–2.2 mm long, 0.3–0.5 mm wide, erect, irregularly deciduous; petals cream colored, 2.6–6.5 mm long; claw linear, 1.4–4.1 mm long, 0.3–0.5 mm wide, hispid, without epidermal papillae, the upper one-fifth irregularly connivent; limb 1.2–2.5 mm long, 0.8–1.5 mm wide, ovate, acute, hispid; stamens well exserted, 5–10 mm long, coiled in bud; filaments without epidermal papillae; anthers 0.3–0.5 mm wide; pollen 23.5–29.4 micra in diameter;



style 3.7–11 mm long; mature fruit 1.6–3.1 mm long, 0.7–1.6 mm wide at the base, and 0.7–0.9 mm wide at the apex, obscurely five-ribbed or smooth, hispid to densely hispid with pointed, antrorsely barbed hair to 0.17 mm long; seed 1.6–2.5 mm long, 0.7–1.3 mm wide. Chromosome number,  $n = 23$ .

Type. Valley of the Rio Gila, Arizona, *Thurber*, June, 1850 (GH).

Distribution (fig. 5). Frequent in dry sandy places, sandy plains, desert washes, dry stream beds, or gravelly places below 4,000 ft., from Inyo Co., California, to Nevada, Arizona, Sonora, and Lower California.

Although this species is the most widely distributed of the five, it is morphologically uniform and only two distinct population groups have been noted and only one of these is given subspecific recognition in this study. Subspecies *gilmanii* is restricted to Inyo Co., California and will be discussed below. The other morphologically distinct populations are distributed in Imperial Co., California, and Baja California. The leaves on plants from these areas are on the average slightly smaller than *P. thurberi* ssp. *thurberi* and are closely appressed to the stems. The remainder of the vegetative and floral characters are within the range of plants of *P. thurberi* ssp. *thurberi* from other areas and for this reason we have not accorded subspecific recognition to these populations.

#### KEY TO SUBSPECIES

- Leaf and stem pubescence harsh, retrorsely appressed on the stems, stamens longer than 6 mm, widely distributed and common throughout the deserts of California, Arizona, Nevada, Baja California, and Sonora 3a. ssp. *thurberi*  
Leaf and stem pubescence very soft, perpendicular to the stems, stamens less than 6 mm long, restricted to Inyo Co., California . . . . 3b. ssp. *gilmanii*

3a. PETALONYX THURBERI ssp. THURBERI. Plants 3–8 dm high; current seasons growth 22–45 cm long; stems grooved, hispid, with retrorsely appressed hair; leaves 0.6–4.5 cm long, 0.2–1.4 cm wide, lanceolate to lance-ovate, acute to acuminate, cuneate to truncate, somewhat shiny, hispid on both surfaces; petals pale cream to white, 2.6–6.5 mm long; stamens 6.0–10.0 mm long; style 5.0–11.0 mm long. Chromosome number,  $n = 23$ .

Distribution (fig. 5). Frequent in dry sandy places, Lower Sonoran Zone, Creosote Bush Scrub, *Covillea* and *Artemisia* belts, Mojave and Colorado deserts, from Inyo Co., California, to Nevada, Arizona, Sonora, and Baja California.

Specimens examined. *Petalonyx thurberi* ssp. *thurberi* frequently is collected and is well represented in U.S. herbaria. Over 150 collections have been annotated.

3b. PETALONYX THURBERI ssp. *gilmanii* (Munz) Davis & Thompson, n. comb. *Petalonyx gilmanii* Munz, Leaflet West. Bot. 2:69. 1938. Plants up to 10 dm high; current seasons growth 12–21 cm long; stems not grooved, densely hispid with long hair, perpendicular to the stems; leaves 0.4–2 cm long, 0.4–1.3 cm wide, deltoid-ovate, acute to abruptly

acuminate, truncate to cordate-clasping, dull, never shiny, densely hispid on both surfaces; petals pale cream, 2.9–4.1 mm long; stamens 5–7.5 mm long; style 3.7–6 mm long. Chromosome number,  $n = 23$ .

Type. Ryan Wash, Death Valley, at 1500 ft. elevation, Inyo Co., California, *M. French Gilman 1568*, May 20, 1937 (POM 228696; Iso-type frag. CAS).

Distribution (fig. 5). Rare in washes and canyons, restricted to Inyo, California.

Specimens examined. CALIFORNIA. Inyo Co.: along road to Ryan, Death Valley, *Davis 170*; Cottonwood Canyon, Panamint Mountains, *Coville & Gilman 308*; 20 miles N of Stovepipe Wells Hotel, *Coville & Gilman 156*; Furnace Creek Canyon, Funeral Mountains, *Coville & Funston 356*; 5 miles NW of Saratoga Springs, *Coville & Funston 249*; Furnace Creek, Death Valley, *Parrish 10047*; Ubehebe Crater, Death Valley, *Kerr* in 1940; Ubehebe Crater Wash, *Gilman 2681*, *3374*, and *3377*; Slopes of Ubehebe Crater, *Gilman 2101*; Trona highway, Panamint Valley, *Twisselman 5843*.

In general, ssp. *gilmanii* has smaller flowers, broader leaves, and longer finer pubescence than ssp. *thurberi*. In addition, the stem hair is erect in *gilmanii* instead of appressed as in *thurberi*, and the current seasons growth generally is shorter than in *thurberi*.

4. PETALONYX NITIDUS Watson, Am. Nat. 7:300. 1873. *Petalonyx thurberi* var. *nitidus* (Watson) M. E. Jones, Contr. West. Bot. 12:16. 1908. Suffructicose with many erect branches, 1.5–4.5 dm high; current seasons growth 13–37 cm long, to 8 mm wide, not grooved, grey-green to dull green, scabrous with short, pointed antrorsely barbed hair, mostly antrorsely appressed; older stems straw-colored to dark gray; leaves petiolate, similar in size along the branches, 1.5–4.5 cm long, 1–3 cm wide, ovate to broadly ovate, acute to shortly acuminate, obtuse to rarely truncate, serrate to coarsely few-toothed (teeth 0.7–3 mm long and 2–8 on each margin), dark green, vernicose, muricate-scabrous on both surfaces with short, pointed, antrorsely barbed hair and on the margins with short, truncate, antrorsely barbed hair; petiole 0.8–5 mm long; inflorescence a terminal bracted raceme, 10–30 flowered, 3–4.5 cm long, not particularly elongated in fruit; pedicels 1–2 mm long; large bractlet 4.8–13.2 mm long, 2.1–7.9 mm wide, lance-ovate, acuminate, truncate, crenate with 3–7 teeth on each margin, scabrous with short, pointed, antrorsely barbed, appressed hair on both surfaces, and short, stout, truncate, retrorsely barbed hair on the margins; lateral bractlet 1–5 mm long, 1–2.4 mm wide, elliptic to ovate, acute to shortly acuminate, crenate along the basal margins, hispid; sepal lobes 1.4–3 mm long, 0.5–0.8 mm wide, irregularly deciduous; petals cream colored, 5–11 mm long; claws linear, 3.9–7 mm long, 0.3–0.4 mm wide, hispid along the upper one third, the upper one fourth connivent, the lower portion without epidermal papillae; limbs 1.5–3 mm long, 1.7–1.9 mm

wide, ovate, acute; stamens well exerted, 7–14 mm long, filaments with scattered epidermal papillae at the base; anthers 0.5–0.7 mm wide; pollen 24–29 micra in diameter; styles 8–15 mm long, usually shorter than the stamens; mature fruit five nerved and five ribbed, 1.3–3.1 mm long, 1–1.5 mm wide at the base, 0.7–0.8 mm wide at the apex, hispid with short, slightly tapered, truncate, retrorsely barbed hairs to 0.08 mm long; seed 2–2.2 mm long, 1.2–1.3 mm wide. Chromosome number,  $n = 23$ .

Type. Southern Nevada, *Wheeler* in 1871 (GH).

Distribution (fig. 5). Common in rocky canyons, washes of open desert, and sandy road banks above 3500 ft. Mojave Desert; Creosote Bush Scrub; Joshua Tree Woodland; and Pinyon-Juniper Woodlands. Inyo and San Bernardino counties of California, to southern Nevada, southwestern Utah, and northwestern Arizona.

Specimens examined. *Petalonyx nitidus* is well represented in U.S. herbaria and we have annotated over 50 collections.

We have encountered one collection of *P. nitidus* that falls well outside of the normal distribution of this species. This collection by Marcus Jones from Yucca, Arizona, is labeled *Jones 4483*, May 15, 1884. Although Jones' itinerary indicates that he was collecting around Yucca on May 15, 1884, it is also recorded that *number 4483* was collected on Sept. 11, 1884 at El Paso, Texas. The uncertainty concerning the collection is unfortunate since some of the specimens appear to be vegetatively intermediate between *P. thurberi*, which Jones did collect from Yucca, Arizona (*Jones 3936*, May 20, 1884) and *P. nitidus*. The presence of *Jones 4483* probably accounts for the inclusion of *P. nitidus* in the *Flora of the Sonoran Desert* (Shreve and Wiggins, 1964).

5. PETALONYX PARRYI A. Gray, Proc. Am. Acad. 10:72. 1874. *Petalonyx nitidus* ssp. *parryi* (A. Gray) Urban & Gilg, Nova Acta Acad. Leop.-Carol. 76:20. 1900. Fruticose, 8–15 dm high; stems of the current season usually less than 13 cm long, to 10 mm wide, not grooved, pale green to straw-colored, scabrous with scattered, short pointed, retrorsely barbed hairs, perpendicular or antrorsely appressed; older stems white-grey to dark grey; leaves petiolate, similar in size along the stems, 1.5–4 cm long, 1.2–3 mm wide, oblong-ovate to broadly elliptic, acute to obtuse, obtuse, entire or crenate (teeth 0.3–1.2 mm long and 5–12 on each margin), grey-green to yellow-green, usually not shiny, muricate-scabrous with short, pointed, strongly appressed hairs on both surfaces and short, pointed, strongly curved hairs on the margins; petiole 0.5–2.3 mm long; inflorescence a naked, spikelike, raceme, congested apically, up to 65 flowered, 4–8 cm long, elongated somewhat in fruit, the lower fruit fallen; pedicels 1–2.5 mm long; large bractlets 6.3–14 mm long, 2.4–10.1 mm wide, lanceolate to lance-ovate, acuminate, obtuse to truncate, crenate to dentate basally with 3–13 teeth per margin, hispid to scabrous with short, pointed, antrorsely barbed, ap-



pressed hair on both surfaces and short, truncate, retrorsely barbed hair on the margins; lateral bractlets 2.5–2.7 mm long, 1.3–1.6 mm wide, ovate, acuminate, dentate-crenate basally, hispid; sepal lobes 2.5–4 mm long, 0.5–0.9 mm wide, erect, irregularly deciduous; petals cream colored, 10–15 mm long; claws linear, 6.3–9.8 mm long, 0.3–0.4 mm wide, the upper one-half connivent, no epidermal papillae basally; limb 2.9–5 mm long, 1.7–2.3 mm wide, ovate, acute to obtuse, hispid; stamens well exerted, 11–17 mm long, filaments without epidermal papillae; anthers 0.6–0.8 mm wide; pollen 24–28.1 micra in diameter; style 11–15 mm long, generally shorter than the stamens; mature fruit five nerved and five ribbed, 2–4 mm long, 1.5–1.6 mm wide at the base, 0.8–0.9 mm wide at the apex, hispid with short, conical, truncate or pointed hairs, antrorsely barbed, to 0.15 mm long; seed 2.5–2.6 mm long, 1–1.2 mm wide. Chromosome number,  $n = 23$ .

Type. St. George, southern Utah, *C. C. Parry* 75, 1874 (GH). According to Parry (1875, p. 144) the type collection was taken from a single plant "within a stone's throw of the great Mormon Temple."

Distribution (fig. 5). In dry washes and on low slopes, usually on white to grey clay soils and below 3000 ft.; from Coconino and Mohave counties, Arizona, to southern Utah and Nevada.

Specimens examined. *Petalonyx parryi* is well represented in U.S. herbaria and over 25 collections have been annotated.

Although very similar to *P. nitidus* in floral morphology, *P. parryi* is vegetatively distinct. For example, *P. parryi* is woodier, and the leaf margins are crenate rather than dentate as in *P. nitidus*. The morphological distinctions between the two are quite sharp, and these along with ecological differences support the maintenance of these two as separate species.

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# MACNAB CYPRESS IN NORTHERN CALIFORNIA: A GEOGRAPHIC REVIEW

J. R. GRIFFIN AND C. O. STONE

Wolf's (1948) monograph on the American cypresses is an excellent taxonomic and geographic study. Recent activities of the State Cooperative Soil-Vegetation Survey, however, have uncovered some distributional data about cypresses that were not available to Wolf. Much of the information concerns the little-known northern groves of MacNab cypress, *Cupressus macnabiana* A. Murr., in Shasta and Tehama counties.

MacNab cypress was probably discovered in Shasta Co. in 1854. The exact locality of the type collection cannot be determined. Published material still does not adequately describe the distribution and ecology of this cypress which is scattered as small groves or as larger clusters of thickets around the Sacramento Valley (fig. 1, table 1). Ironically, the only well publicized and easily accessible stand of MacNab cypress in this region was destroyed recently by the construction of Whiskeytown reservoir.

In Lake Co. and adjacent areas of the Coast Range, MacNab cypress populations geographically overlap those of *C. sargentii* Jeps. Within these areas *C. sargentii* often dominates in lower canyon slopes and creek bottoms. Morphological "intermediates" between these two species have been observed by several collectors. Wolf (1948), however, discounted suggestions of introgression between *C. sargentii* and *C. macnabiana* in the Napa-Lake Co. area. Our observations support this suggestion.

MacNab cypress is geographically isolated from *C. bakeri* Jeps. in the Sierra Nevada-Cascade and Siskiyou Mountains. Jepson (1909; 1931) and Wolf (1948) have clearly outlined the morphological and ecological differences between these two species.

## REVIEW OF SHASTA-TEHAMA CYPRESS REPORTS

Since Sudworth (1908) included *C. bakeri* in *C. macnabiana*, we should first consider these *C. bakeri* reports. In northeastern Shasta Co., a large cypress stand occurs near Timbered Crater (Stone, 1965). Although discovered in 1898, it was apparently unknown to Sudworth. In 1909 Jepson described this Timbered Crater cypress as *C. bakeri*.

Sudworth (1908) specifically mentioned seven *C. macnabiana* localities in Shasta and Tehama counties. Wolf transferred one of these seven to *C. bakeri*. Sudworth's "west of Burney Creek" grove is the western outpost of the large Burney Springs *C. bakeri* population. Another locality vaguely cited by Sudworth as "small grove at base of Lassen buttes" was probably based on another ambiguous report of the same Burney Springs population. Sudworth also mentioned a cypress locality at "South Fork of Cow Creek," nine miles southwest of the Burney

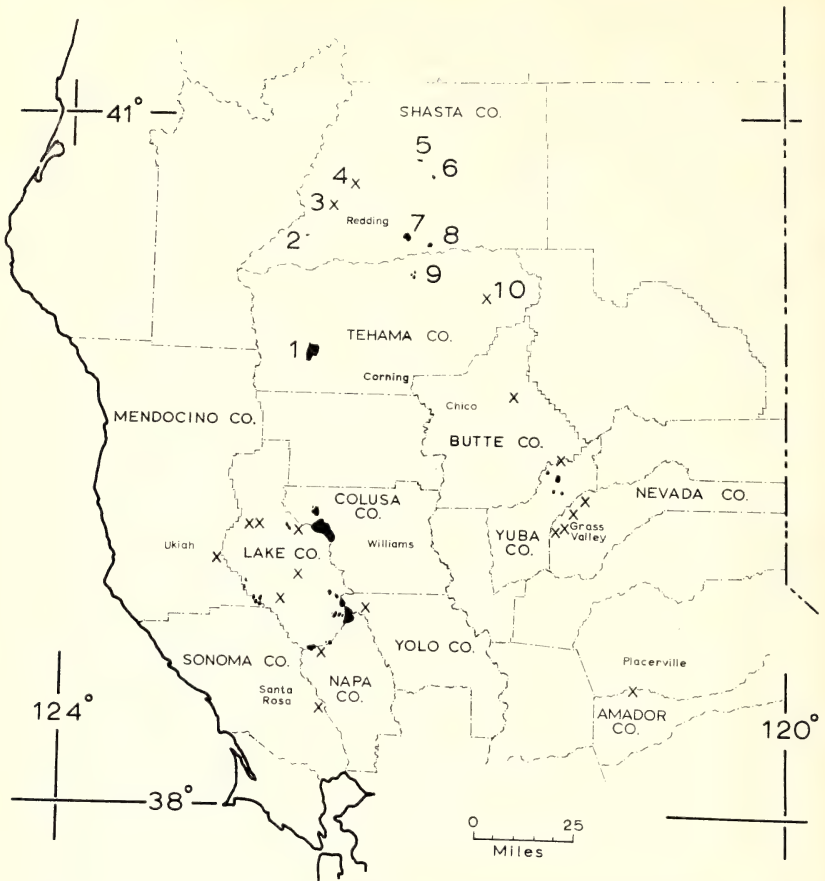


FIG. 1. Diagrammatic map of *Cupressus macnabiana* distribution in northern California. Shaded areas represent stands mapped by the State Cooperative Soil-Vegetation Survey. Crosses indicate unmapped stands listed in Tables 1 or 2. Numbered stands are described in Tables 2 and 3.

Creek grove. Through the efforts of E. L. Little, Jr. we examined many unpublished notes and maps and found that Sudworth's report was based on a letter dated Jan. 19, 1907, from J. C. La Plant. The letter mentioned two thrifty trees in the area. We checked this region but found no cypress. The trees that were there were most likely the montane *C. bakeri* and not the foothill *C. macnabiana*.

Wolf became skeptical of Sudworth's notes after he found *Juniperus californica* Carr. at the "Butte Creek" (Battle Creek) locality. There is no cypress now in the section cited (table 2). Sudworth had established the locality from another report forwarded by La Plant on Feb. 13, 1907. La Plant's report may have been prompted by a rumor about the Ash Creek cypress grove three miles north of the juniper locality.

TABLE 1. GENERAL LOCALITY AND ASSOCIATED SOIL PARENT MATERIAL OF MACNAB CYPRESS POPULATIONS. SHASTA AND TEHAMA CO. STANDS ARE DESCRIBED IN TABLES 2 AND 3

Locality	Dominant Soil Parent Material <sup>1</sup>	Remarks
AMADOR CO.		
E of River Pines	Ultrabasics (serpentinite)	In T. 8 N. not T. 9 N. as listed by Wolf, 1948.
NEVADA CO.		
NE of Grass Valley	Ultrabasics (serpentinite)	
SW of Grass Valley	Metavolcanics (greenstone with serpentinite veins) and basic intrusives (gabbro)	<i>Hall 10182 UC</i> and Wieslander, 1928.
NE of Nevada City	Probably basic intrusives or ultrabasics	<i>Burk 10 UC</i>
YUBA CO.		
All mapped stands	Basic intrusives (gabbro)	Not "granitic" as listed in Wolf, 1948.
E of Forbestown	Ultrabasics (serpentinite)	<i>Sias UC</i>
BUTTE CO.		
Magalia	Ultrabasics (serpentinite)	
SONOMA CO.		
Hooker Canyon	Pliocene pyroclastics (tuff)	Small groves 4 miles N. and 2 miles SE of main grove reported in 1905.
NAPA, LAKE, COLUSA, MENDOCINO CO.S		
All major populations mapped by SV Survey and most small unmapped stands.	Ultrabasics (serpentinite)	
High Valley Ridge	Metasediments	{ <i>Zinke 196 UC</i> Example of minor nonserpentine grove in Lake Co.
YOLO CO.		
Cedar Basin	Sandstone	

<sup>1</sup> Calif. Div. Mines. Chico sheet (1962), Santa Rosa sheet (1963), Ukiah sheet (1960), Geologic map of California, San Francisco. All rocks were mapped as Mesozoic in age except for Sonoma Co. tuff.

Another area of confusion in Sudworth's published list is near Paynes Creek, Tehama Co. The "Payne Creek" report was probably based on the same trees as the "Inskip" report.

Kildale's "Trinity River" collection (table 2) is confusing because no other Trinity Co. cypress report has come to our attention. Sargent's (1922) mention of "Trinity County between Shasta and Whiskeytown" obviously referred to the Shasta Co., Whiskeytown grove. Kildale's specimen label stated that it was collected on the "Trinity River, at Betty May Mine." Unfortunately, no Betty May mine has ever been recorded in the legal files of Trinity Co. A mine with a similar name did exist in the Clear Creek mining district near Whiskeytown.

TABLE 2. SUMMARY OF MACNAB CYPRESS STANDS REPORTED IN SHASTA AND TEHAMA COUNTIES

General Area	Specific Locality	Status in Wolf (1948)	Remarks
"Butte Creek"	"Sec. 25, T. 30 N., R. 1 W." (Sudworth, 1908)	Discredited.	<i>Juniperus californica</i> present at this locality.
Paynes Creek	"Near Payne post office and on Payne Creek Hill. . . ." (Sudworth, 1908)	Discredited.	Same as Inskip Butte stand.
Trinity River	" . . . at Betty May Mine, Trinity County." <i>Kildale 10276</i> (DS)	This one 1930 collection mentioned.	Probably a Whiskeytown collection.
Raglin Ridge (1)	Sec. 20, 21, 22, 27, 28, 29, T. 25 N., R. 7 W.	Not known to Wolf	Shown on S-V map 31 D-3, 42 A-2. Portions on public lands.
Rainbow Lake (2)	SW-¼, Sec. 31, T. 31 N., R. 7 W.	Not known to Wolf	Shown on S-V map 31 A-2. Private land.
Whiskeytown (3)	Sec. 16, 21, T. 32 N., R. 6 W.	Described in detail.	Entire stand destroyed by construction of Whiskeytown Lake.
Kennett (4)	"Along road off U.S. 99, leading to Kennett . . ." <i>Bacigalupi 2386</i> (DS)	This one 1934 collection mentioned.	These trees can no longer be found.
Montgomery Creek (5)	Sec. 35, T. 35 N., R. 1 W.	Not known to Wolf.	Shown on S-V map 22 B-3. Private land.
Round Mountain (6)	Sec. 26, T. 34 N., R. 1 W.	Not known to Wolf.	Shown on S-V map 22 B-3. Private land.
Lack Creek (7)	Sec. 36, T. 31 N., R. 2 W. Sec. 31, T. 31 N., R. 1 W.	Not known to Wolf.	Shown on S-V map 32 A-1. Private land.
Ash Creek (8)	Sec. 11, 12, T. 30 N., R. 1 W.	Not known to Wolf.	Shown on S-V map 33 B-2. Portions on public lands.
Inskip Butte (9)	"T. 29 N., R. 1 W." (Sudworth, 1908)	Discredited.	Shown on S-V map 33 B-3. In Sec. 22, 23, 27. Private land.
Mill Creek Rim (10)	"Sec. 5, T. 27 N., R. 3 E."	Mentioned by Jepson (1931), not discussed by Wolf.	This stand has not been relocated.



We probably have not located the exact point of the Kennett collection (table 2). Owing to the many road relocations and widespread habitat disturbance since Shasta Dam was built, it is not surprising that these trees cannot be found. Some cypress might still survive in the brush above Shasta Lake, but no significant population exists in the area today.

The six previously unreported cypress stands, in Shasta and Tehama counties (table 2), have probably been known to a variety of non-botanists for a long time. But no published references to these groves or herbarium specimens from them before the Soil-Vegetation Survey have come to our attention. Sudworth had limited information about at least one of these groves. C. Hart Merriam mentioned MacNab cypress near Round Mountain in a 1908 note.

Population samples from all localities (except Whiskeytown) listed in Table 3 are available at the Pacific Southwest Forest and Range Experiment Station, Redding.

#### GROVE DESCRIPTIONS

The Shasta-Tehama cypress groves have physiographic and broad climatic similarities. All are above the valley terraces (table 3). Summers are dry and hot, and the abundant fuel creates extreme fire hazards in all of them. Vegetationally, the groves are part of a complex mosaic of chaparral and woodland communities. They grow above the oak savannas and just within the lower fringes of the coniferous forest. Three widely distributed shrubs—*Arctostaphylos viscida* Parry, *Ceanothus cuneatus* (Hook.) Nutt., and *Eriodictyon californicum* (H. & A.) Torr.—are associated with all the groves. *Pinus sabiniana* Dougl. grows in, or adjacent to, all the groves. *Salvia sonomensis* Greene carpets the ground around many of the groves. Yet, these MacNab cypress habitats reveal considerable diversity.

Climate. While emphasizing the dry nature of *C. macnabiana* habitats, Wolf (1948) underestimated their mean annual precipitation. He generalized that most localities had about 20 inches of rainfall, noting Whiskeytown as an exception with 35 inches. Current data raise this Whiskeytown estimate nearer to 50 inches (table 3). The Montgomery Creek grove is the wettest in the Shasta-Tehama area, with 60 inches or more. Other groves to the south in the Sierra Nevada also receive heavy precipitation. The Inskip locality has half as much rainfall as the wetter areas, and it may be as dry as any of the Coast Range localities.

No long-term temperature data are available for any of these localities. Although their heat regimes appear superficially similar, aspect and elevational differences are great enough so that some temperature variation should be present. Edaphic factors appear more helpful in explaining the distribution of these disjunct populations than climatic patterns.

Soils and Vegetation. Although many of the Sierra Nevada and Coast Range populations are associated with ultrabasic rocks (table 1),

TABLE 3. GEOGRAPHIC COMPARISON OF SHASTA AND TEHAMA COUNTY  
MACNAB CYPRESS POPULATIONS

Population Locality	Size	Elevational Range	Mean Annual Precipitation <sup>1</sup>	Soil Parent Material <sup>2</sup>	Soil (B Horizon) Characteristics
	acres	feet	inches		
Raglin Ridge (1)	1,500	2300-3200	45-50	Mesozoic ultrabasics (serpentinized)	Shallow, rocky, clay loam, neutral.
Rainbow Lake (2)	22	1700-1900	45-50	Mesozoic ultrabasics (serpentinized)	Shallow, rocky, clay loam, neutral.
Whiskey-town (3)	300	1000-1200	45-50	Devonian Meta-rhyolite	Shallow, clay loam, strongly acid.
Montgomery Creek (5)	75	1800-2200	60-65	Eocene non-marine sediments	Moderately deep, rocky, clay, strongly acid.
Round Mountain (6)	23	2500-2600	55-60	Eocene non-marine sediments	Moderately deep, rocky, clay, strongly acid.
Lack Creek (7)	350	1400-1550	30-35	Pleistocene basalt	Moderately deep, rocky, clay, strongly acid.
Ash Creek (8)	200	2800-2900	30-35	Pleistocene basalt	Moderately deep, very rocky, silty clay, moderately acid.
Inskip Butte (9)	100	1850-2250	25-30	Recent basalt	Extremely rocky, silt loam.

<sup>1</sup> Calif. Dept. Water Resources. Shasta County Investigation Bulletin 22, Sacramento. 1964.

<sup>2</sup> Calif. Div. Mines. Redding sheet (1962), Westwood sheet (1960), Geologic map of California. San Francisco.

only two of these populations grow on serpentinite (table 3). The widely scattered thickets on Raglin Ridge are on part of an extensive ultrabasic tract resembling the Lake Co. cypress areas. The little Rainbow Lake grove is within a smaller, perhaps less serpentinized ultrabasic mass 30 miles to the north of Raglin Ridge.

The chaparral associated with these two groves has a similar aspect, for the serpentine endemic scrub oak, *Quercus durata* Jeps., is abundant in both. Shrubs of *Rhamnus californica* ssp. *crassifolia* (Jeps.) Wolf occur in both. The Raglin Ridge cypress area appears to have a richer shrub flora, including *Ceanothus jepsonii* Greene and *Garrya condonii* Eastw. The higher elevation cypress groves on Raglin Ridge are interspersed with dense *Pinus attenuata* Lemm. thickets.

The edaphic situation at Whiskeytown was unique in relation to all other MacNab cypress localities. The cypress was concentrated on a bench of meta-rhyolite. Portions of the area had fine textured, mottled

soil horizons that restricted deep rooting. Wolf described the area as having "sterile nearly white rocky soil." McMillan (1956) characterized it as "fine whitish alluvium" from granite. He sampled soils at six different cypress localities, and Whiskeytown had the lowest pH (4.98). The chaparral in the basin was relatively poor in species. The cypress here was also mixed with *Pinus attenuata* thickets.

The Round Mountain and Montgomery Creek groves are only five miles apart. Both are on part of an extensive formation of loosely consolidated sandstone and gravel. These soils are mostly covered with woodland at all elevations.

The Lack Creek and Ash Creek groves are also about five miles apart. Both are on reddish soils derived from basalt. Although deep in spots, these soils are liberally mixed with large boulders. Such zonal woodland soils occur on tens of thousands of acres of volcanic flows to the east of the Sacramento Valley. The chaparral around these two populations has a great diversity of species present. Both have dense clumps of shrubby *Quercus garryana* Dougl. The Lack Creek community includes such species as *Fraxinus dipetala* H. & A., *Fremontodendron californicum* (Todd.) Cov., and *Ptelea crenulata* Greene which are not present at the other Shasta-Tehama cypress localities. A disjunct *Adenostoma fasciculatum* H. & A. population (Wislander 338, UC) also occurs at Lack Creek. Although it is the dominant shrub on millions of acres in the hills west of the Sacramento Valley, *Adenostoma* is rare in the volcanic region to the east of the Valley.

Inskip Butte contrasts with all the other *C. macnabiana* localities. The "soil" on this small, recently formed volcano consists of silty material in the fractures of the porous basalt. Annual grassland and oak savanna grow on older volcanic materials which surround the butte. Northeast slopes of the butte support a poor pine forest, while the cypresses occur on the lower west slopes in depauperate chaparral communities. Associated with the cypresses on Inskip Butte are thickets of a disjunct *Pinus attenuata* population.

Intensive study of aerial photographs and limited field work have proved insufficient to relocate the Mill Creek stand. There is no reason to doubt that the specimen sent to Jepson (1931) was *C. macnabiana* and that it came from the vicinity of the Mill Creek Canyon in Tehama Co. A small grove may still be there.

#### DISCUSSION

The relatively little-known stands discussed here do not significantly extend the total distribution of *C. macnabiana*. The rejection of the Trinity River locality even restricts the northwestern corner of the range. But these data do supplement our knowledge of how this species is scattered about the Sacramento Valley. The Whiskeytown stand was most inadequate to illustrate the range of edaphic and climatic conditions that this cypress can tolerate in its northern distribution.



The Raglin Ridge and Rainbow Lake stands appear to be a northern extension of the common Coast Range distribution pattern. More intensive study of the ultrabasic zone across Glenn Co. may yet reveal some small MacNab cypress groves in the gap between the Colusa and Tehama County populations (fig. 1). One difference in these two northern Coast Range MacNab cypress communities is the absence of any other cypress species. In the Lake Co. and adjacent serpentinite areas, *C. sargentii* grows in or near many *C. macnabiana* stands.

The eastern Shasta-Tehama stands may be viewed as an extension of the Yuba and Butte Co. populations. Again, closer study of the most inaccessible brushy canyons might reveal a few isolated trees or small groves that have escaped botanical notice. In contrast to the Coast Range situation, no edaphic trend is apparent along this Sierra Nevada-Cascade distribution.

From the standpoint of base exchange properties, there might be some similarities between the basic extrusive, basic intrusive, and ultrabasic soils represented here. The Kennett grove which must have been on greenstone also fits into this pattern. Even the Montgomery Creek and Round Mountain sediments were derived largely from basic igneous materials. But if there are any soil chemical similarities, they seem to be obscured by the gross differences in physical properties. The contrast between the reddish clay loam over clay at Lack Creek, which may be more than five feet deep, with the greyish silty loam at Inskip, which may be only a few inches deep, is startling.

Gankin and Major (1964) discussed the distributional patterns of many disjunct and endemic species. They noted that disjunct species frequently exploited non-zonal sites "where competition is decreased by some kind of extraordinary soil parent material or other continuously effective disturbance of climax vegetation development." Most of these MacNab cypress groves fit conveniently into the context of their discussion. The Inskip Butte grove is a good example. The zonal vegetation appears to be excluded from the recent volcanics because of insufficient soil development. In the absence of savanna-woodland species, the cypress can survive on the lava.

Perhaps of greater interest are the Lack Creek and Ash Creek populations, that seem to depart from this general pattern. They grow on widely distributed geologic materials with normal degrees of soil development for this area. Although these cypresses compete with zonal chaparral species on zonal soils, they seem to be in no imminent danger of losing out. Edaphic factors are not obviously involved with the particular location of these cypress groves. Other environmental factors that may contribute to the competitive advantage of cypress in these localities are not apparent. Since it is difficult to explain the presence of the cypresses ecologically, they must grow on these zonal soils because of historical reasons. The coincidental presence of the isolated *Adenostoma*



colony at Lack Creek suggests that some peculiar set of circumstances has influenced this vegetation in the past.

Three of the Shasta-Tehama cypress groves are closely associated with *Pinus attenuata* populations. Two other groves are not far from *P. attenuata* areas. Several ecological similarities between these two different fire-adapted conifers are apparent. The historical events that have contributed to the widely scattered distribution of *P. attenuata* probably have also influenced the distribution of MacNab cypress. The pine, however, has a broader range of ecological tolerances. Its range closely approximates the combined range of the three cypresses mentioned here: *C. macnabiana*, *C. sargentii*, and *C. bakeri*.

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## A NEW SPECIES OF PRIMROSE FROM NEVADA

NOEL H. HOLMGREN

***Primula nevadensis*** N. Holmgren, sp. nov. Folia erecta, scapos plerumque superantes, oblanceolata vel lineari-oblanceolata, (2.5)-5-10-(12) cm longa, 0.6-1-(1.5) cm lata, distaliter grosse dentata vel enterdum subtiliter dentata vel etiam integra, ad apicem obtusa vel

acuta, raro rotundata; scapa 3.5–9–(11) cm alta, pauciflora, bracteis involucri (3)–4–8–(11) mm longis; flores heterostyli, calyce 6–10 mm longo, tubo lobos superanti, corolla lobis violaceis patentibus emarginatis, tubo in flore brachystylo (7)–8–10–(11) mm longo, limbo (4)–6–10–(11) mm lato, tubo in flore dolichostylo (6)–7–9–(10) mm longo, limbo (5)–7–11–(12) mm lato.

Herbage minutely glandular puberulent; leaves erect, usually surpassing the scapes, oblanceolate to linear oblanceolate, gradually tapering into a winged petiole, (2.5)–5–10–(12) cm long, 0.6–1–(1.5) cm wide, coarsely toothed beyond the broadest point to sometimes entire, obtuse or acute, rarely rounded at apex; scapes 3.5–9–(11) cm high, bearing an umbel of (1)–2–3–(8) flowers; involucre bracts as many as the flowers and opposite the pedicels, the largest one (3)–4–8–(11) mm long, lanceolate, the smallest rudimentary and up to 3 mm long, triangular to lanceolate; pedicels 5–15–(23) mm long; calyx pale green and densely farinose, especially in a rhomboid patch below each cleft, to purplish and scarcely farinose, tube (3.5)–4–7–(8) mm long, the teeth 2–4 mm long, triangular; corolla purple in bud, lobes violet at anthesis with a dark purple ring around the throat, throat yellow to yellow-orange inside, yellow or brown with a violet tinge outside, tube yellow to white; flowers heterostylous, the measurements of the tube and limb varying accordingly, the lobes alike in all flowers; in thrum flowers (anthers above the stigma), tube (7)–8–10–(11) mm long, limb (4)–6–10–(11) mm wide, in pin flowers (anthers below the stigma), tube (6)–7–9–(10) mm long, limb (5)–7–11–(12) mm wide; corolla lobes (4)–5–9–(10) mm long and (3)–5–8–(10) mm broad, emarginate to obcordate; anthers yellow to yellow orange, about 2 mm long; pollen grains tetrahedral with convex walls, measurements in pin flowers about  $15.6\mu$  and in thrum flowers about  $21.8\mu$ ; capsules 5–6 mm long, 4 mm thick, elliptical, within a persistent and slightly accrescent calyx.

Type. *Holmgren, Reveal & LaFrance 2216*, south slope of Mt. Washington, Snake Range, White Pine Co., Nevada, at about 11,500 feet elevation, July 20, 1965 (NY-holotype, 34 isotypes distributed).

Additional specimens. Nevada. Nye Co.: Troy Peak, Grant Range, *Worth & Priest 601* (NY); *Holmgren, Reveal & LaFrance 2213* (34 sheets distributed). White Pine Co.: Mt. Washington, Snake Range, *Holmgren & Reveal 1653* (14 sheets distributed); Snake Range, Lincoln Peak, *Holmgren, Reveal, & LaFrance 2219* (35 sheets distributed).

*Primula nevadensis* is known from only the Grant Range and the Snake Range of east central Nevada, where it seems to be restricted to limestone outcrops at elevations above 11,000 feet. Similar habitats exist in the two intervening ranges, the Egan and Schell Creek ranges, and also in two other nearby ranges, the White Pine Range just north of the Grant Range and the Mt. Moriah region of the northern Snake Range. With the assistance of James L. Reveal and Charles LaFrance, we explored these areas and failed to find it.

In its known localities *P. nevadensis* is very common in crevices of limestone rock and on open gravelly slopes and ridges with scattered *Pinus aristata* Engelm., *Ribes montigenum* McClat., *Eriogonum holmgrenii* Reveal, *Phlox hoodii* Richards., *Aquilegia caerulea* James, *Castilleja nana* Eastw. and krumholz of *Picea engelmannii* Engelm.

The nearest relatives of *P. nevadensis* are *P. cusickiana* Gray, *P. maguirei* L. Williams and *P. angustifolia* Torr. These four species are the New World representatives of the section *Nivales* Pax. *Primula nevadensis* is probably more closely allied to *P. maguirei* and *P. cusickiana* than to *P. angustifolia*. The distinguishing characteristics are shown in the following key:

- Inflorescence with 1, rarely 2 or 3 flowers; bracts 1.5–3–(4) mm long; alpine areas of the southern Rocky Mts. . . . . *P. angustifolia*
- Inflorescence usually with more than 1 flower; bracts mostly 3–9 mm long.
  - Corolla tube 1.5–2 times as long as the calyx; leaves (7)–10–25 mm wide; calciphile; known only from Logan Canyon of the Bear River Range in northern Utah, at lower elevations. . . . . *P. maguirei*
  - Corolla tube 1–1.5 times as long as the calyx; leaves 4–10–(15) mm wide.
    - Scape longer than the spreading leaves; leaves mostly 2.5–5 cm long; foothills and montaine slopes in central Idaho and northeastern Oregon, below timberline. . . . . *P. cusickiana*
    - Scape usually overtopped by the erect leaves; leaves mostly 5–10 cm long; calciphile; alpine areas of east central Nevada. . . . . *P. nevadensis*

Our discovery of this plant was not entirely by accident. Both James L. Reveal and I had heard independently of an undescribed primrose from eastern Nevada. So while collecting in the Snake Range in the summer of 1964 we were both consciously looking for it, but after a week of collecting on the quartzite and granite slopes of Wheeler Peak and upper Snake Creek drainage we had given it up as not being a Snake Range inhabitant. Because of this it came as a real thrill when we stumbled across it a few days later on the limestone slopes of Mt. Washington only a couple of miles south of Snake Creek.

That winter in the New York Botanical Garden herbarium I discovered a C. R. Worth & Amel Priest collection in the unidentified primroses. Worth responded to my inquiry with a letter giving me the history of its discovery in the Grant Range. In the summer of 1945 Rogers McVaugh showed him a specimen he had collected on Troy Peak, which Worth recognized as being distinct from anything he knew. He collected it himself in 1947 and again in 1958. He sent a specimen to William Wright Smith at Edinburgh who did not want to commit himself without more material to study from. To my knowledge these are the only collections of it prior to my own.

I am very grateful to Arthur Cronquist for the opportunity to do field work supported by his NSF grant and for his assistance in preparing this note, C. R. Worth for his help, Arthur H. Holmgren for loaning materials, and James L. Reveal for his suggestions and assistance in the field.

New York Botanical Garden, Bronx



## REVIEWS

*Biographies of Nevada Botanists, 1844-1963.* By OLGA REIFSCHNEIDER. 165 pp. University of Nevada Press, Reno. 1964. \$4.95.

A little more than a hundred years ago William Henry Brewer wrote from Virginia City that "Nevada Territory embraces over eighty thousand square miles, but is nearly all desert. It has just been made a state, but I see no elements here to make a state. It has mines of marvelous richness but it has nothing else . . . The climate is bad, water bad, land a desert, and the population floating." Nevada, the "land between," the well-nigh country, was more often sampled by the naturalist on the road than as a destination in itself. Nevada's explorers seldom lingered. Exhausted, short of food and funds, wearying of the desert, they were often desperate to reach their Eldorado. For that reason they sometimes passed by some remarkable plants such as the composite *Hecastocleis*. On the other hand that Fremont should stumble upon *Arctomecon*, a papaveraceous genus of restricted range, is a wonder of botanical history. Nevada specimens were often fragmentary and it was not until Sereno Watson threw his energies into the King Expedition that the content of the Nevada flora out of the conestoga tracks came to be known, and even then specimens were sparse by modern standards.

After eight pages of the "physical background" of Nevada and a general account of the history of botanical exploration in the state there begins a chronological album of forty-seven portraits usually with a page or two of biographical matter opposite. About half of the portraits are heretofore unpublished and comprise a notable biohistorical record. A smaller cut would usually have improved the published photograph. Contemporaries will be the historic figures of tomorrow and it is important to record information and portraits of them, a successful facet of the author's book. The source of the portrait, the photographer's name, and the date, are more to be valued than the credit line. The bibliography as it stands is a mixture of technical papers on Nevada botany written by persons included in the book, and biographical accounts of the authors; these two aims should have been divorced with attention given primarily to biographical references. For periodicals pagination as well as volume numbers should have been cited. Separate maps for the collectors, or a map for two or more collectors where their areas of activity will not be easily confused, in the manner of Geiser's *Naturalists of the Frontier*, would have been preferable to the "Botanical collection areas" (p. 17). There is need for a complete index of persons. All of these comments are directed toward the preparation of the second edition which we hope will be forthcoming.

Fred Hebard Hillman introduced his *Early Flora of the Truckee Valley* (1895) by saying it was "issued as a preliminary step toward a future and more complete Flora of Nevada." Comparably Mrs. Reifschneider's album of botanical explorers may be described as a pioneer botanical history of Nevada. *Corrigenda* or *addenda* are arranged in chronological order of the year of the collector's visit to Nevada:

1841. William Gambel (1821-1849), Nuttall's protégé, journeyed across the Virgin River country but doubtfully made any plant collections there. A few of Gambel's specimens are encountered in the British Museum (Natural History) being originally a part of Nuttall's herbarium.

1846. Joseph Burke (fl. 1841-1853) may have collected plants along his route from Fort Hall to Willamette Valley. Historian Dale Morgan of the Bancroft Library will presently publish additional information on Burke.

1854. James Aitken Snyder (d. 1900) assisted Lt. E. G. Beckwith in the exploration of the western Great Basin. Lt. Beckwith assumed command of Gunnison's Expedition after the massacre of Capt. Gunnison in October, 1853. Beckwith listed Snyder's collections in the second volume of the Pacific Railway Reports. These Snyder specimens have been cited frequently as Beckwith's (for example, King Report, pp. 36 and 109). Susan G. Stokes, *Genus Eriogonum*, p. 43, 1936, credits the type of *Eriogonum nutans* T.&G. as being Beckwith's specimen though it was



more accurately Snyder's. Snyder's field localities are few: Agate Pass of the Quartz Mountains (*Pac. R.R. Rep.* 2:121) and "Nevada: canyon at the eastern base of the Sierra Nevada," the type locality for *Eriogonum nutans*. Snyder collected *Dodecatheon integrifolium* and the type of *Viola beckwithii* "in a canyon between Great Salt Lake and the Sierra Nevada"! but Viola Brainerd Baird, in *Wild Violets of North America*, p. 212, 1942, fixes the locality as "Diamond Mt., Eureka Co., Nevada, 1854, Snyder." The well known botanical roster in volume two of the *Botany of California* (1880) mentions Dr. J. A. Snyder but J. H. Barnhart doubts the appellation "Dr."

1885. Ezechiel Jules Remy (1826-1893), French natural history collector, travelled from San Francisco to Salt Lake City in the company of Julius Lucius Brenchley, ornithological collector and author, and recorded his impressions of Nevada in chapters one and two of his *Journey to Great-Salt-Lake-City* (London, 1861). Remy took a particular interest in the genus *Eriogonum* and his specimens, never numerous, are in the Natural History Museum, Paris.

186—? Hiram G. Bloomer (1821-1874) is frequently mentioned in the King Report (pp. 27, 140, 153, 166, etc.). His collections made about Mr. Davidson, Steamboat Springs, Washoe Valley, Cedar Hill, and Virginia City, and preserved in the California Academy were mostly lost in the San Francisco fire of 1906.

186—? C. Herbert Dorr collected the type of *Audibertia dorrui* named by Albert Kellogg in 1863 and presumably taken near Virginia City, but the specimen is lost. The King Report (p. 44) refers to Dorr's collection of *Spraguea paniculata* from the western base of Mt. Davidson. Was he related to Sullivan Dorr (1778-1858) of Boston and Providence? Papers of the Dorr family are preserved at the Essex Institute, Salem, Mass.

1862. Charles Lewis Anderson. W. H. Brewer and C. L. Anderson are mistakenly cited in Mrs. Reifschneider's bibliography as the authors of Asa Gray's paper on Anderson's and Brewer's collections. Interesting biographical facts on Dr. Anderson will be found in "The History of Botanical Collecting in the Santa Cruz Mountains of central California" by J. H. Thomas (*Contr. Dudley Herb.* 5:147-148, 1961).

1863. William Henry Brewer (1828-1910) collected on the Truckee River, at Aurora, and in the Esmeralda district, and in 1864 about Virginia City. Farquhar published an interesting letter from this period of Brewer's life in *Up and Down California*, pp. 551-559, 1930.

1863-64. John Allen Veatch (1808-1870), mining engineer, associate of Dr. Albert Kellogg, and active in the early years of the California Academy, was a resident of Virginia City in 1863-64 where he was evidently engaged in medical practice (as well as mining activities) while his son Andrew Allen Veatch was superintendent of the reduction works of the central mill. The King Report (p. 133) cites a Veatch collection from the Washoe Mts.

1865. John Torrey (1796-1873) collected at Carson City, Washoe Lake (his no. 123), and about Steamboat Springs, Washoe Valley (no. 372), as cited in the King Report. This visit of 1865 was a stopover on a confidential mission to California as an assayer for the Treasury Department.

1866. John Gill Lemmon (1832-1908) is said (p. 39) to have sent 50 plant specimens to Henry N. Bolander, "the only botanist on the Pacific Coast at that time." Lemmon was himself the source of that erroneous statement, which certainly disregarded Dr. Kellogg at the Academy! Here we encounter the gentle rivalry that existed between Kellogg and Asa Gray for the description of novelties that were being discovered every year, and Lemmon's allegiance to Gray. The history of the portrait of Lemmon, whose middle name was Gill not Gibbs, is interestingly told in *Madroño* 5:77, 1939, where it was first published.

1867. William More Gabb (1839-1878), paleontologist, geologist, assistant to J. D. Whitney on the California State Geological Survey, collected insects as well as plants. Gabb is mentioned in the King Report as having collected on the "sage plains of western Nevada" (p. 117), south of Walker's Lake (p. 118), and along the

state boundary. For references to Gabb and others in this list see my roster in the *Century of Progress in the Natural Sciences*, 1853–1953, p. 49. 1955.

1867. William Whiman Bailey (1843–1914), son of Jacob Whitman Bailey, was the first botanist of the King Expedition; he was evidently not a Doctor of Medicine as cited by Reifschneider (p. 47). "Entering Nevada from California," wrote Sereno Watson in the *Botany of the Fortieth Parallel*, xxii, 1871, "collection was commenced on the 16th of July, 1867, in the valley of the Truckee River by Mr. W. W. Bailey, botanist of the expedition, and was continued through the season but confined wholly to the district between the Virginia and the Pah-Ute Mountains. The summer was already so far advanced that the earlier vegetation had disappeared and little was left to reward the collector. Some gleanings were however made, especially in the West Humboldt Mountains [type of *Ivesia baileyi* was taken in Wright's Canyon, 7,000 ft., in Sept., no. 346] and in the bottoms and sinks of the Truckee, Carson, and Humboldt Rivers." Bailey's health continued to decline during the winter of 1867 and Watson succeeded him in the spring of 1868.

1868–69. Richard Harper Stretch (1837–1923), entomologist, is mentioned several times in the King Report (pp. 13, 63, 98, 177, 216, etc.) as having botanized at Carson City and Washoe Valley. He spent the winter of 1868–69 studying the Comstock Lode for the U.S. Geological Survey. Stretch named the Nevada buckmoth (*Hemileuca nevadensis*), moths being his particular interest.

1877. When Joseph Dalton Hooker toured the West with Asa Gray by rail they "left the direct route at Reno," wrote Gray to Engelmann, "went to Carson City, with detour to Virginia City, —queer place; first got hold of *Pinus monophylla*, but there no fruit. Hired conveyance to take us from Carson right across the Sierra Nevada via Silver Mt. to Calaveras Big Trees." (J. L. Gray, *Letters of Asa Gray*, 2:674. 1893).

1878. Charles Frederick Sonne. Portrait published in *Madroño* 2:115. 1934.

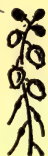
1880. William Hillman Shockley (1855–1925), mining engineer, who as partner in the firm of Zabriskie and Shockley, lived in Candelaria, Nevada, from 1880 to 1893, botanized "on the side" in Esmeralda County and the White Mts. He took the type of *Lupinus shockleyi* at Soda Springs and discovered two composites, *Acamptopappus shockleyi* Gray, and the endemic monotypic mutisiaceous genus *Hecastocleis* Gray. In 1878 Shockley was collecting ferns for D. C. Eaton in the limestone sinks of Florida. Jepson published a biographical sketch and portrait in *Madroño* (2:26–28. 1931).

1890. Vernon (Orlando) Bailey (1864–1942), biologist, started his career with the Death Valley Expedition. On May 1st, 1890, Bailey collected two new species, *Abronia orbiculata* Standl. and *Arctomecon merriami* Cov. between Cottonwood Springs and Las Vegas Ranch.

1898. Carl Albert Purpus (1853–1941), one of a triumvirate of Mexican botanical explorers—Palmer, Pringle, and Purpus—, crossed the Charleston Mountains from Pahump Ranch to Indian Springs, visiting Clark Canyon on the way, and collecting the types of *Arabis pendulina* Greene and *Frasera induta* Tidestr.

1927. Charles Leo Hitchcock (1902– ) botanized in the Charleston Mountains where he took the type of *Lesquerella hitchcockii* Munz and *Erigeron uncialis* var. *conjugens* Blake. He returned to botanize in the Charleston Mountains with George Jones Goodman (1904– ) in July, 1930.—JOSEPH EWAN, Tulane University, New Orleans.

Botany



# MADRÑO

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# NATURAL HYBRIDIZATION BETWEEN ENCELIA AND GERAEA (COMPOSITAE) AND SOME RELATED EXPERIMENTAL INVESTIGATIONS

DONALD W. KYHOS

During the spring of 1965, while collecting in the California and Arizona deserts, I was surprised to encounter what appeared to be natural hybrids between an annual, *Geraea canescens* Torr. & Gray, and a shrub, *Encelia farinosa* Gray. Both of these species are exceptionally common over large areas and often create some of the most spectacular floral displays on the lower deserts of California, Arizona, and Mexico. Despite their great numbers and frequent sympatry, hybrids between these two rather different taxa have not heretofore been reported. It would appear, however, that such hybrids are not rare, inasmuch as eleven were found within a two-week period, in four well separated areas of the Colorado River valley (table 1).

It would be of unusual interest to learn that an "intergeneric" hybrid could be experimentally produced between a woody shrub and an herbaceous annual, as has been done in *Parthenium* by Rollins (1946). The potential significance of such a hybrid, however, is much greater when it occurs naturally, as in the case of *Encelia* and *Geraea*, since if such an unusual hybrid has any fertility at all, it may serve to exchange genetic material between taxa that ordinarily would be assumed to have taken independent courses of evolution. With this possibility in mind, an investigation was undertaken to determine the capacity for gene exchange in these hybrids, as well as examine other aspects of their hybridity.

## MATERIALS AND METHODS

All chromosome materials were fixed in a solution of one part glacial acetic acid, three parts absolute alcohol and the cytological investigations were done by the conventional aceto-carmin squash technique. For the paper chromatography studies one gram of leaves from a given plant were placed in 10 ml of one percent HCL in methyl alcohol. The leaves were then thoroughly ground up and allowed to stand in the dark for 12 hours before 25 drops of this solution were applied to #1 Whatman filter paper. After a thorough drying the filter paper was placed in a chromatography chamber where the first dimension was developed in a solution of one part acetic acid, one part water, and three parts tertiary butyl alcohol, for 22 hours. Then the filter paper was thoroughly dried and the second dimension development in the chamber was completed in four hours, in a solution of 15 percent glacial acetic acid in water. After drying, the filter paper was examined in

TABLE 1. HYBRID LOCALITIES

---

65-130	Along road to Earp, Calif., 2.8 mi E of Vidal Junction, San Bernardino Co.
65-158	Dome Valley, Ariz., 5.4 mi N of U. S. Hwy 80, Yuma Co.
65-159	same as above.
65-221	Near road to Lake Havasu, Calif., 18.5 mi E of U.S. Hwy 95, San Bernardino Co.
65-222	same as above.
65-225	Near road to Lake Havasu, Calif., 18.2 mi E of U.S. Hwy 95, San Bernardino Co.
65-226	same as above.
65-229	Near U.S. Hwy 95 2.6 mi S of San Bernardino Co. line, Riverside Co.
65-230	same as above.
65-231	same as above.
65-232	same as above.

---

sunlight, in UV light, in UV light with ammonia fumes, and finally after spraying with a 2% ferric chloride solution.

In all experimental crosses discussed in this paper, each plant necessarily served as both a maternal and paternal parent. Because *E. farinosa*, *G. canescens*, and their hybrid are all strongly self-incompatible, no emasculation was necessary and therefore each experimental cross was done by simply rubbing flowering heads gently together. This action exchanges pollen between capitula of different plants, thus simultaneously effecting reciprocal pollination.

Voucher specimens are deposited in the University of California, Davis, herbarium.

#### NATURE OF THE SPECIES AND THEIR HYBRIDS

*Habitats of the hybrids.* Nine of the eleven hybrids grew in obviously disturbed sites at road margins; a frequently observed phenomenon in plants. The remaining two hybrids from Dome Valley, Arizona are of greater interest, since they occurred on small hills that bore no signs of disturbance. The occurrence of these plants in undisturbed sites, suggested that such hybrids might have existed in sufficient numbers to permit the exchange of genes between *Geraea* and *Encelia*, even prior to man's disturbing influence. Such hybrids might also be expected to survive in naturally disturbed areas, although no examples of this kind were observed in the course of this investigation.

*Characteristics of the parent species and hybrids.* *Encelia farinosa* and *G. canescens* are very easily distinguished. The former is a grayish, rounded shrub that is intricately branched and moderately woody. In the more open desert it usually attains a height of two to three feet, but in more protected canyons and washes it may exceed five feet. *Geraea canescens*, in contrast, is a distinctly green, often sparsely branched, erect annual, which usually attains a height of only one to two feet. A closer inspection reveals a number of additional features, both vegetative and reproductive, which further differentiate these spe-

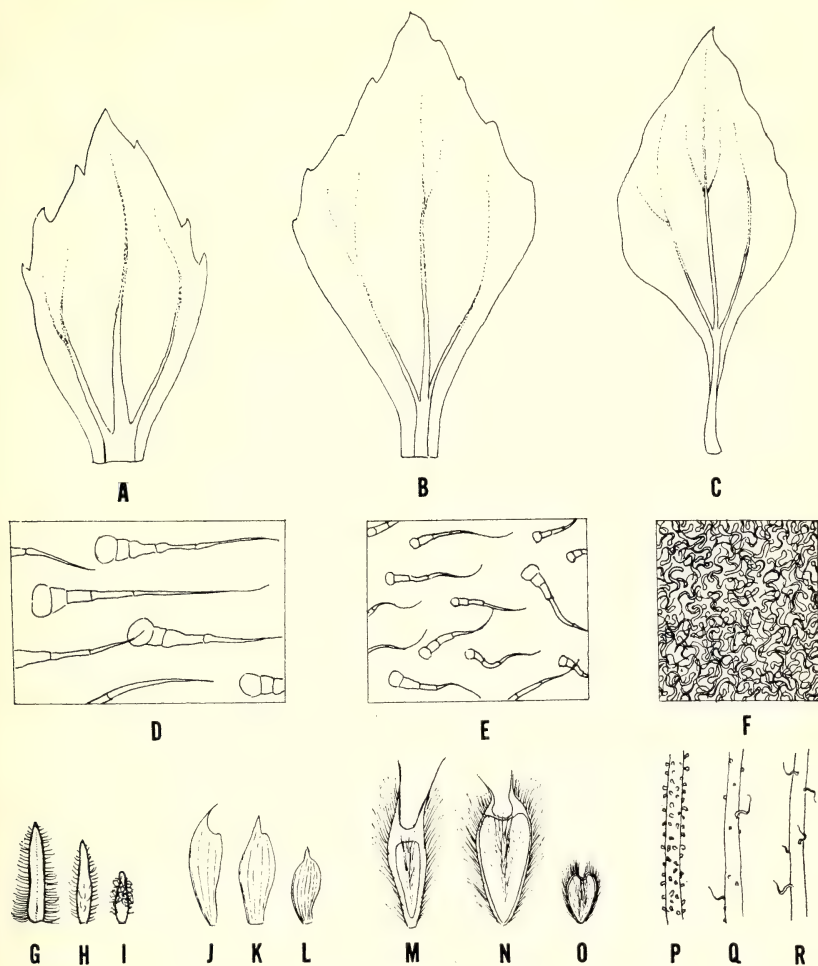


FIG. 1. Various organs and morphological details of *Geraea canescens*, *Encelia farinosa*, and their  $F_1$  hybrid. In each series of three organs or structures, *G. canescens* is positioned at the left, the  $F_1$  hybrid in the center, and *E. farinosa* is on the right: A-C, view of the upper side of leaves,  $\times \frac{3}{4}$ ; D-F, pubescence on the under leaf surface,  $\times 12$ ; G-I, involucral bracts,  $\times 1\frac{1}{2}$ ; J-L receptacular bracts,  $\times 1\frac{1}{2}$ ; M-O, achenes,  $\times 2$ ; P-R, distal portion of the peduncle,  $\times 2$ .

cis (fig. 1). Although the hybrids between *E. farinosa* and *G. canescens* exhibit some gigas features, their morphology is for the most part predictably intermediate, with two notable exceptions. One of the exceptional plants is hybrid 65-130, which has a leaf pubescence remarkably similar to *Encelia farinosa*, whereas all of the other hybrids are intermediate for this character. Since all other characteristics of 65-130



are those expected of an  $F_1$  hybrid, it appears most probable that its *Encelia*-like leaf pubescence has not resulted from genetic recombination beyond the  $F_1$  level, but instead represents part of the variation that can occur in this particular  $F_1$  combination. The other exception to intermediacy involves disk floret color. In this instance two of the hybrids, 65-130 and 65-229, have brownish-purple disks and another, 65-231, has brownish anthers with yellow disk corollas. All of the other hybrids have yellow florets throughout their flowering heads. The dark color of the disk florets in these hybrids was undoubtedly inherited from *E. farinosa*, because *G. canescens* uniformly has yellow florets, whereas some individuals of *E. farinosa* have brownish-purple and others have yellow disks in the areas where these hybrids occurred. Dark colored disks in *Encelia* are inherited in a dominant fashion, with a relatively simple genetic basis (Kyhos, unpublished). It seems likely that disk color is inherited in the same manner in the *Encelia*  $\times$  *Geraea*  $F_1$  hybrid. Thus the presence of brownish-purple and yellow disks in different hybrid individuals cannot in itself be considered evidence of hybridization past the  $F_1$  stage.

When discovered, the eleven hybrids were of widely different ages, ranging from very small seedlings to vigorous plants, up to three feet in height and in full flower. From the three largest hybrids, 65-130, 65-158, and 65-159, cuttings were made which slowly took root and developed into robust plants. The remaining hybrids were small enough to be removed in their entirety and brought successfully into cultivation. Under the conditions of cultivation these hybrids have maintained a perennial growth habit. It is not known whether they can exist as perennials in nature, although there is a suggestion that this is possible. One of the hybrids (65-130) had earlier grown to a height of about three feet, but when discovered it had already died back to its base. A renewed growth and flowering had occurred from this basal portion, suggesting that this individual had been established for more than one season.

Chromatographic studies provided additional evidence that these hybrid individuals are of the  $F_1$  generation. By means of paper chromatography over 30 chemical constituents, i.e. spots, were identified from each of the parent species and from among these, four occurred exclusively in *E. farinosa* and another five were found solely in *G. canescens*. In each of the putative hybrids a complementation of these spots invariably occurred, providing strong evidence for the  $F_1$  nature of these plants (fig. 2).

*Meiosis in the parent species and hybrids.* Both *E. farinosa* and *G. canescens* consistently form 18 pairs of chromosomes. Pairing of the chromosomes is readily observed in these species and no meiotic irregularities have been observed in the more than ten individuals examined of each of these species from widely scattered areas of California, Arizona, and Mexico.



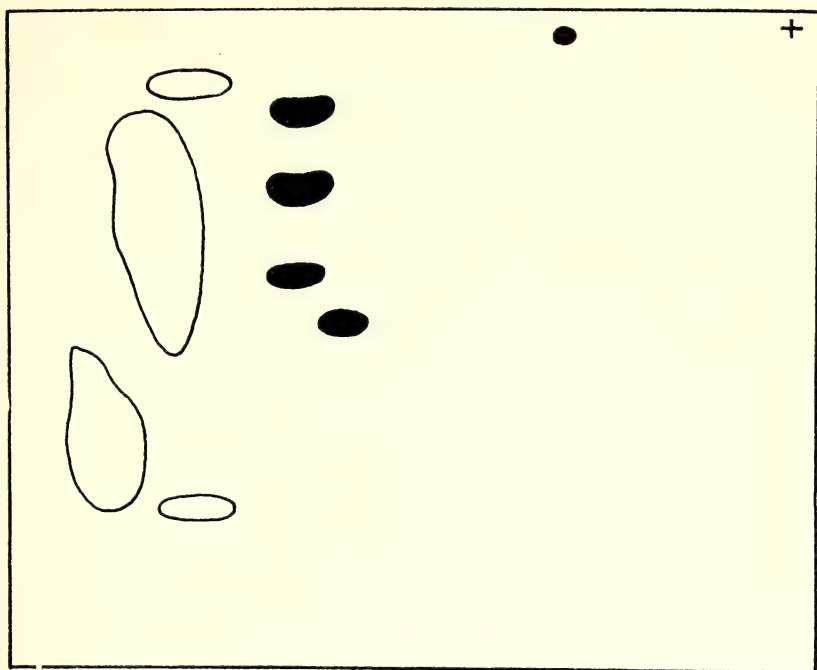


FIG. 2. Diagrammatic representation of a paper chromatogram of the *Geraea canescens*  $\times$  *Encelia farinosa* F<sub>1</sub> hybrid. The dark spots are those specific to *G. canescens* and the unshaded spots are those peculiar to *E. farinosa*. In the putative F<sub>1</sub> hybrids all of these spots are complementarily present as shown in this illustration. The cross in the upper right hand corner of the chromatogram is the origin.

In sharp contrast, the pachytene and subsequent stages of meiosis in the putative hybrids consistently reveal a general lack of chromosome pairing. Moreover, when pairs were formed, they were only very loosely held together, as opposed to the very definite bivalent connections in the parent species. The few chromosomes pairs that occur appear to result from very localized synapsis. A considerable variation exists in the metaphase I-anaphase I chromosome behavior of the hybrids. These plants displayed two distinct types of meiotic behavior, which varied greatly in frequency from one floret to another, even in the same flowering head. In one case only one to three chromosome pairs are usually formed, while the numerous univalents seem to segregate to the anaphase poles at random. In the other case the chromosomes fail to pair at all, and at what would normally be meiotic metaphase, all of the chromosomes divide equationally to produce two equivalent daughter nuclei, each with 36 chromosomes. The resulting telophase I nuclei are subsequently separated by cytokinesis; a phenomenon which normally does not take place in members of the Compositae until after the second meiotic division. There is no evidence that a second meiotic division

occurs in these cells. Each of the two cells continue to develop inside the original PMC wall where normally four cells would be found. It is apparent that not all of these cells develop into mature pollen grains, as indicated by the generally low frequency of filled, presumably functional pollen grains (table 2). In the PMCs where the chromosomes appear to segregate at random to the anaphase I poles, cytokinesis occurs in a normal fashion, i.e. after the second meiotic division. The great majority of these cells possessed obviously unbalanced chromosome numbers and as would be expected seldom produce mature pollen grains. Usually only one of these two types of meiotic behavior predominates in a given floret, although some florets contained approximately equal numbers of both kinds of PMCs. This variation in meiotic behavior was observed in chromosome materials collected from the three largest hybrid plants as they grew in the wild state and thus represents the variation in meiosis that existed under natural conditions.

*Fertility of the hybrids.* An estimate of male fertility in the hybrids was obtained by staining the pollen grains with cotton blue in lactophenol and determining the proportion of empty or partially empty grains to those completely filled with cytoplasm. The number of filled pollen grains in most of the hybrids ranged around one per cent, with two outstanding exceptions (table 2). The  $F_1$  hybrids 65-221 and 65-222 had apparently good pollen at frequencies of 12% and 67.5%, respectively. In the hybrid 65-221 the completely filled pollen grains were relatively large (33-37 microns) and four-pored, in contrast to the smaller (24-27 microns), three-pored grains of both parent species. The larger size and the occurrence of four-pores suggest that these pollen grains have twice the usual chromosome number; a conclusion which is further supported by the occurrence of large (34-37 microns), often four-pored pollen grains in two of the polyploids produced experimentally from these  $F_1$  hybrids. The relatively high incidence of large, four-pored, apparently functional pollen grains in hybrid 65-221 could be explained by assuming that a greater proportion of the cells, which form unreduced nuclei, ultimately produce functional pollen grains. In the case of the hybrid 65-222 all of the apparently normal pollen grains are consistently three-pored like the parent species, but these grains are the size of the pollen produced by experimental *Geraea* X *Encelia* polyploids, and thus presumably contain twice the normal number of chromosomes. This finding indicates a close correlation of ploid-level with pollen size, but gives no indication of a correlation of pore number with the degree of ploidy; a conclusion which is confirmed by the occurrence of large pollen grains (33-37 microns) that are invariably three-pored in one of the experimentally produced *Geraea* X *Encelia* polyploids. An attempt was made to test the validity of the relatively high pollen fertility estimate obtained for hybrids 65-222 by using this hybrid in a series of controlled crosses. Twenty controlled crosses of hybrid 65-222 to each of the parent species produced no filled seeds, which is the same result that was obtained with

TABLE 2. HYBRID FERTILITIES

Collection number	Male Fertility			Female Fertility	
	Sample size	Number of filled pollen grains	Percent filled grains	Number of seeds with embryos	Number of F <sub>2</sub> seeds that germinated
65-130	500	7	1.4	2	2
65-158	500	7	1.4	..	..
65-159	500	4	0.8	..	..
65-221	500	60	12.0	..	..
65-222	1000	675	67.5	2	..
65-225	pollen sterile			4	1 died as a seedling
65-226	500	17	3.4	..	..
65-229	500	3	0.6	4	1
65-330	500	6	1.2	..	..
65-231	500	3	0.6	1	..
65-232	died as seedling				

all of the other F<sub>1</sub> hybrids. Another 30 controlled crosses of 65-222 to the other F<sub>1</sub> hybrids produced only two filled seeds, neither of which germinated. Apparently 65-222 has no greater female fertility than the other F<sub>1</sub> hybrids. It is possible that 65-222 is as pollen fertile as the cotton blue staining method indicates, but this can not be established by crosses to the other F<sub>1</sub> hybrids, since female fertility, which is consistently low in these hybrids, would be expected to be the important limiting factor in producing an F<sub>2</sub> progeny.

A total of 92 seeds was collected from the three largest hybrids (65-130, 65-158, and 65-159) when they were first encountered in the field, however, none of these fruits contained embryos. Twenty controlled crosses of the ten surviving hybrids were made to each of the parent species, but these likewise failed to produce any fruits with normal embryos. Fifty controlled crosses of the F<sub>1</sub> hybrids in various combinations among themselves, however, produced a total of 1,186 apparently fully developed seeds, of which 13 contained embryos (table 2). Four of these 13 seeds germinated and three of these F<sub>2</sub> plants survived to maturity.

*The F<sub>2</sub> generation.* All three surviving F<sub>2</sub> plants originated from two maternal parents, each with brownish-purple disk florets. Two of the three F<sub>2</sub> plants came from the only filled seeds produced by hybrid 65-130 and like their maternal parent, both had brownish-purple disk florets. These F<sub>2</sub> plants were extremely vigorous, under greenhouse conditions, and were nearly double the size of their parents in stature as well as the size of their individual organs. Morphologically both of these F<sub>2</sub> individuals closely resembled the majority of the F<sub>1</sub> hybrids. Their



maternal parent, it will be recalled, differed from all of the other  $F_1$  hybrids in that its leaf pubescence was strikingly similar to *E. farinosa*. Both of these  $F_2$  individuals, however, had a leaf pubescence that was most like the intermediate condition of the other  $F_1$  hybrids.

The exaggerated size of these  $F_2$  individuals suggested that they were polyploid. A cytological examination confirmed this supposition. Each of these plants formed 36 pairs of chromosomes at meiosis and their estimated pollen fertility was at a comparatively high level (86.0% and 71.3%) relative to the  $F_1$  hybrids. In attempting to reconstruct the origin of these  $F_2$  individuals, it is probably impossible to completely rule out apomixis accompanied by spontaneous chromosome doubling as one possibility. A more likely mode of origin, however, is from the union of unreduced gametes. This interpretation is supported by the frequent occurrence of anaphase I and II meiotic nuclei with 36 chromosomes in the  $F_1$  hybrids, as well as by the occurrence of large, often four-pored, pollen grains, that presumably have double the normal chromosome number.

A third mode of origin, which requires the union of two haploid gametes, each with a balanced complement of 18 chromosomes, followed by chromosome doubling, is so improbable that it need not be considered.

The third  $F_2$  individual is essentially like the other two, both in its morphology and exaggerated size. It differs conspicuously only in that its disk florets are a comparatively light brownish-purple. The cytology of this individual is more interesting, since it provides evidence of the origin of this plant. Instead of possessing a  $2n$  chromosome number of 72 and forming 36 pairs of chromosomes at meiosis, this individual had a  $2n$  chromosome number of 65 and consistently formed 29 pairs and 7 single chromosomes in the 40 PMCs observed. Seemingly, such a cytological condition could only arise by the union of an unreduced gamete with another gamete having an unbalanced chromosome number of 29. At meiosis, in an individual possessing this combination of chromosomes, the 29 chromosomes from the unbalanced gamete would all have homologues with which to pair, while the remaining seven chromosomes, that were contributed by the unreduced gamete, would be left without pairing partners and thus should consistently occur as univalents, which apparently they do. Assuming that the 36 univalents in the  $F_1$  hybrids randomly segregate at anaphase I, then the chance of an unbalanced gamete arising that contained 29 chromosomes would be scarcely more than one in 5000. An examination of anaphase I PMCs in the two  $F_1$  hybrids that were the maternal parents of the  $F_2$  plants, revealed that while the equal and near equal segregations of chromosomes, e.g. 18:18, 19:17, and 20:16, approximated a random distribution, the very unequal chromosome segregations, such as 25:11, 26:10, and 27:9, were clearly not random. The latter categories consistently occurred in much higher frequencies than chance would predict. This nonrandomness probably accounts for the recovery of a  $2n = 65$  plant in a sample of only 3  $F_2$



plants. The cytology of this  $F_2$  individual demonstrates the participation of an unreduced gamete in its origin and thus supports an interpretation of the origin of the other two tetraploid  $F_2$  plants by the union of unreduced gametes.

#### DISCUSSION

From this investigation it has been shown that previously undetected  $F_1$  hybrids are produced, perhaps yearly, between a moderately woody shrub, *E. farinosa*, and an herbaceous annual, *G. canescens*. The occurrence of at least some of these  $F_1$  hybrids in apparently undisturbed sites suggests that appreciable numbers of these hybrids may also have existed in the long period before man's activities created the numerous disturbed areas that are so wide-spread today. Thus, it seemed possible that such hybrids may have permitted an exchange of genetic material between these rather different taxa for a very long time. A most important factor influencing such a genetic exchange would be the fertility of the  $F_1$  hybrid. Evidence of pollen fertility and crossing experiments of the  $F_1$ s seems to indicate that an exchange of genes between *Encelia* and *Geraea* is extremely limited, if not essentially impossible. Not only is the fertility of these hybrids extremely low, due to a general lack of chromosome pairing in conjunction with a relatively high chromosome number, but all attempts to backcross these  $F_1$  hybrids to their parent species failed to produce any progeny. On the other hand, 3 polyploid individuals were produced with comparative ease by crossing the  $F_1$  hybrids among themselves. Two of these  $F_2$  individuals were extremely vigorous tetraploids, with the expected increase in fertility, whereas the third  $F_2$  plant approached the tetraploid state, but was deficient for 7 chromosomes and hence, not unexpectedly, had a comparatively low pollen fertility (17.6%). This  $F_2$  individual exhibited the same vigor and gigas features, in greenhouse culture, as the other  $F_2$ s despite its chromosome imbalance.

The ease with which these polyploids were obtained, from the otherwise rather sterile *Encelia*  $\times$  *Geraea*  $F_1$  hybrids, suggests that such tetraploid derivatives are also generated in nature, but apparently have not become established. Such a possibility seems likely, considering the fact that in a two week period two clusters of 4 such hybrids were found. The 4 individuals in each of the clusters were growing within pollination distance of each other, but far enough apart to make it very unlikely that they were from the same parent plants. The frequency and close proximity of these hybrids appears to be more than adequate for the natural production of tetraploid derivatives, particularly considering the long span of time available for the necessary events to occur in. The absence of these tetraploids in nature would seem to result from their elimination by natural selection. The behavior of these hybrids in greenhouse and out-of-doors culture, perhaps provides a clue to their biological failure. As noted earlier, the tetraploids grew very vigorously in greenhouse culture, but when moved outside into mild April weather

and maintained there for the next 5 months, all three of these tetraploids progressively declined in vigor, nearly to the point of death. During this culture regime most of the flowering heads on these plants were extremely deformed and seldom produced any pollen. Upon returning the tetraploids to the greenhouse, they promptly resumed extremely vigorous growth. On the other hand, all of the  $F_1$  hybrids also placed out-of-doors during the same time interval showed no floral deformation or decline in vigor. The inability to withstand even mild environments outside of the greenhouse was thus established as a phenomenon peculiar to the tetraploids, not effecting the very parent individuals from which these tetraploids were derived. The apparent inability of the tetraploids to grow normally outside, may well be the basis for their failure to become established in nature, however, it will be necessary to study many more such polyploids, produced from parents over a much wider geographic range, in order to properly test this explanation.

The few experimental tetraploids produced in this investigation did, however, resolve one question, namely, whether the poor meiotic chromosome pairing in the  $F_1$  hybrids has a genetic or chromosomal basis. The formation of 36 normal meiotic chromosome pairs in the tetraploids, provides strong evidence that very different chromosome arrangements of the parent species, and not genetic factors, are responsible for the greatly reduced meiotic pairing in the  $F_1$  hybrid.

Finally one might ask, does the finding that *G. canescens* and *E. farinosa* hybridize, necessitate any taxonomic revision? In my opinion, the answer to this question is no. In more recent taxonomic treatments *Geraea* and *Encelia* have not been considered congeneric (Abrams and Ferris, 1960; Munz, 1963; Shreve and Wiggins, 1964), however, earlier treatments (Gray, 1873; Hall, 1907) did consider them to be congeners. The mere fact that highly sterile hybrids occur naturally between these taxa, provides no compelling evidence in favor of either of these taxonomic viewpoints. The significant criteria in this case, are to be derived, rather, from classical morphology and perhaps chromatographic evidence. Much additional work, particularly in the latter area is required before a taxonomic revision would be justified.

#### ACKNOWLEDGMENTS

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## SUMMARY

Natural hybridization between *Encelia farinosa* and *Geraea canescens* is reported and the hybrids are described in terms of their morphology, chromatographic features, and their capacity for gene exchange. From the  $F_1$  hybrids, spontaneous tetraploids were derived, which had normal chromosome pairing and restored fertility, indicating that the parent species have fundamentally different chromosome arrangements. The ease with which polyploid derivatives were experimentally obtained from the  $F_1$  hybrids, suggests that they are produced in nature also, but are at a selective disadvantage, and hence have not become established. The taxonomic implications of these findings are considered.

Department of Botany, University of California, Davis

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NEW RECORDS OF MYXOMYCETES FROM  
CALIFORNIA II.

DONALD T. KOWALSKI

The new records of slime molds listed in my first paper (Kowalski, 1966) brought the total number of Myxomycetes recorded in print for California to 165. Since then, two new species have been described from the state (Brooks and Kowalski, 1966; Kowalski, 1966a). Ten new records are reported in this paper. This brings the total number of slime molds found in California to 177 species. This investigation was supported by the National Science Foundation (Grant GB-3865).

The species listed in my first paper were collected exclusively in Butte Co. Since that time, I have collected extensively in Northern California on a line north of Chico. Although a few of the species to be reported are from the Sacramento Valley, and a few from the North Coast, the majority are from alpine regions. The great majority of montane Myxomycetes are found only near the melting snow, but, if no rain has fallen,



they may be found a few hundred yards from any snowbanks. It appears that most species actually form their fruiting bodies under the snow and that as the snow melts back, they are then exposed. This belief is based on the fact that the discovery of plasmodia in the mountains is very rare. They may be found inside or under rotten logs, but practically never out in the open where most of the fruiting bodies are found. The fact that many collections are found part way up shrubs and trees and on top of fallen twigs also reinforces this view.

All collections have been deposited in the Herbarium of the University of Michigan. The names of the organisms are those accepted by Martin (1949) and the numbers are my own.

#### LICEACEAE

*Licea kleistobolus* G. W. Martin. On decayed wood, Lower Bidwell Park, Chico, Butte Co., 2156, Nov. 21, 1965. The sporangia are sessile, bright coppery-brown, and dehisce by a circumscissile performed lid. They are exceedingly tiny, averaging about 0.1 mm in diameter. This species has been found as far west as Colorado and is considered rare. This, however, is undoubtedly due to its inconspicuousness and it may occur throughout the United States.

*Licea variabilis* Schrad. Three collections, all on decayed wood: 5 miles east of Stirling City, 4000 ft., Butte Co., 2063, Aug. 19, 1965; Inskip, 4000 ft., Butte Co., 2082, Oct. 22, 1965; Eagle Lake, 5000 ft., Lassen Co., 2662, April 8, 1966. This taxon is very easy to identify because it is the only truly plasmodiocarpus form in the genus. Most of the plasmodiocarps are black, but a few are light brown in color. It is fairly common at higher elevations and has been reported previously from Washington and Oregon.

#### CRIBRARIACEAE

*Cribraria purpurea* Schrad. On decayed wood, MacKerricher Beach State Park, Mendocino Co., 2385, Jan. 25, 1966. This is a handsome species being bright-reddish-purple in color. This collection is somewhat atypical in that the fruiting bodies are extremely robust, some reaching 5 mm in total height. Most descriptions give 2.5 mm as the maximum total height. However, it is easily determined by its color and the plasmodic granules which are soluble in water. It is not common, but is known from scattered localities across the United States.

*Lindbladia effusa* (Ehrenb.) Rost. On decayed wood, Well's Cabin Campground, 6300 ft., Tehama Co., 1607, July 2, 1965. The fructification is an aethalium in which the individual sporangia are quite distinct. No other member of the family is aethalioid. It is probably closely related to *Cribraria argillacea* (Pers.) Pers., which is practically identical to *L. effusa* except that it does not form an aethalium. It may even be that *L. effusa* is simply a variation of *C. argillacea*. *L. effusa* is relatively common throughout North America in coniferous regions.



## DIANEMACEAE

*Dianema depressum* (List.) List. Three collections, two on decaying bark, 5 miles west of Childs' Meadows, 5100 ft., Tehama Co., 2852, 2856, April 30, 1966, and one on duff, 4 miles east of Stirling City, 4000 ft., Butte Co., 2687, April 9, 1966. This species is distinct in the genus because it is the only member with reticulate spores. These collections vary from most descriptions because the capillitial threads are not penicillate. It is uncommon but has been reported from Washington and Oregon.

## STEMONITACEAE

*Lamproderma cribrarioides* (Fries) R. E. Fries. Four collections, all on decaying bark, 5 miles east of Mineral, 5800 ft., Tehama Co., 2946, 2947, 2950, 2963, May 15, 1966. The spores of this taxon separate it from every other member in the genus. They are distinctly reticulate, the reticulations consisting of raised bands up to  $1.5\ \mu$  high. The spores in these collections are larger than what is given in most descriptions, often being up to  $18\ \mu$  in diameter. It is an exceedingly rare species, being known previously in the United States only from Colorado.

*Lamproderma gulielmae* Meylan. Two collections, both found 4 miles E. of Inskip, 5500 ft., Butte Co., 2806 on decaying leaf and 2813 on decayed twig, April 23, 1966. This species has a silvery-blue peridium with black depressed spots which gives it a netted appearance. Unlike other montane *Lamproderma*'s, which tend to form massive collections, collections of this form usually consist of just a few scattered sporangia. Until now, it also was only known in this country from Colorado.

## PHYSARACEAE

*Physarum crateriforme* Petch. Five collections, four on bark of live oak, Lower Bidwell Park, Chico, Butte Co.: 2089, Nov. 19, 1965; 2111, Nov. 20, 1965; 2152, 2163, Nov. 21, 1965; and on persimmon bark, Lower Bidwell Park, Chico, Butte Co., 2230, Dec. 4, 1965. Typically, the sporangium has a large columella which can vary from white to dark brown, and a dark stripe. These collections are frequently sessile and the columella may be absent. It is thought to be rare, being reported only from Iowa and Kansas in this country. This, however, may be due to the fact that it grows on the bark of living trees and, thus, simply is not found often because few collectors search this type of substrate. During the winter in the Sacramento Valley it was abundant. When conditions were right, practically every rough-barked tree that I searched had this slime mold in great abundance.

*Physarum diderma* Rost. Four collections, all on decaying bark, Lower Bidwell Park, Chico, Butte Co.: 2320, Jan. 2, 1966; 2338, Jan. 8, 1966; 2351, Jan. 15, 1966; 2465, Feb. 7, 1966. The sporangia are sessile, crowded, pure white and have a double wall. Perhaps its most outstanding characteristic, which is not mentioned in most species descriptions, is the presence of a large, globose, hollow, calcareous columella,

situated directly in the center of the sporangium. It has been reported from scattered localities across the United States and on the west coast from Oregon.

#### DIDYMIACEAE

*Diderma ochraceum* Hoffm. On decaying wood, Jedediah Smith Redwoods State Park, Del Norte Co., 2442, Jan. 30, 1966. The sporangia are scattered, sessile, yellowish in color, and the peridium is cartilaginous. This species is apparently quite rare, being found previously only as far west as Tennessee.

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#### NOTES AND NEWS

DR. ELWOOD WENDELL MOLSEED (1938-1967), Assistant Professor of Botany at the University of San Francisco, San Francisco, California passed away on April 4, 1967, after an illness of several months. He was a keen field botanist and one of those rare modern taxonomists with a green thumb. During his all too-short career, he made significant contributions to our knowledge of Mexican and Central American Iridaceae. Plans are under way for the posthumous publication of his manuscripts on *Tigridia* and related genera. His untimely death is mourned not only by his friends and associates in California, but also by those in Mexico where he spent so much time since he began his field studies on *Tigridia* in 1962.

# CYPRESS RUSTS IN CALIFORNIA AND BAJA CALIFORNIA

ROGER S. PETERSON

This study concerns two rust fungi parasitizing cypress (*Cupressus*) in California (United States) and Baja California (Mexico), and the aecial stage of one of them on *Amelanchier*.

The only "rust" of cypress previously known in California was caused by an alga (Wagener, 1948), while no cypress rusts have been recorded in Mexico. Six rust fungi, all in *Gymnosporangium*, have been described from cypress found elsewhere, two of them in North America (Kern, 1964). No sori other than telia have been recorded for rust fungi on *Cupressus*, although a few species of *Gymnosporangium* produce uredinia as well as telia on other genera of Cupressaceae.

Lee Bonar, F. D. Kern, and L. N. Goodding kindly contributed advice and information to this study.

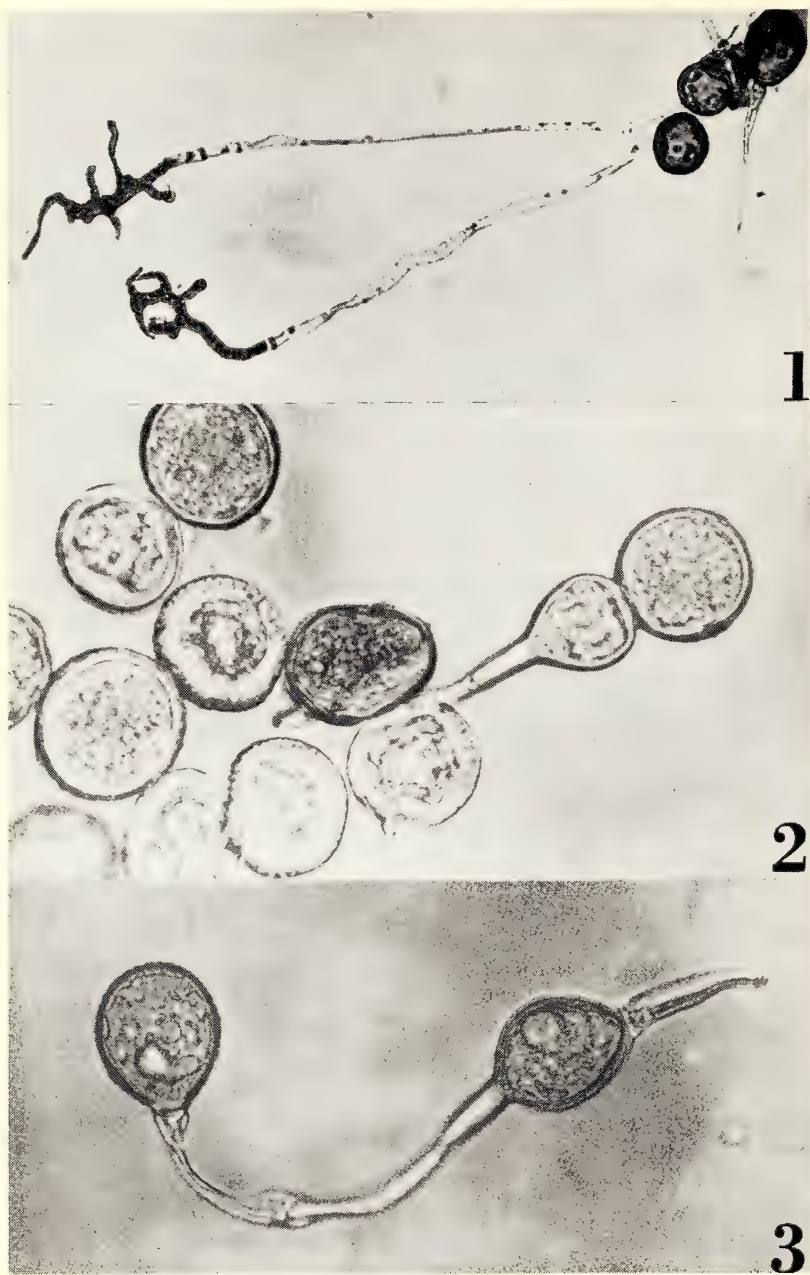
**Uredo cupressicola** R. Peterson, sp. nov. Urediniis planis vel cristatis, exiguis v. ad  $4 \times 7$  mm. magnitudine, cinnamomeo-brunneis; peridio nullo. Urediniosporis late ellipsoideis v. globosis, (13-) 22-24 (-28)  $\times$  (21-) 24-28 (-35)  $\mu$  (sextantibus maximis minimisque separatim inclusis); membrana 1.5-2.0 (-3.0)  $\mu$  crassa, dense induta verrucis 0.3-0.4  $\mu$  diam. minusque 0.5  $\mu$  alt, brunnea, v. sporarum immaturarum crassiore et hyalina; poris germinationis 5-8, plerumque 5-6, papillatis, dispersis; pedicello hyalino, saltem usque 145  $\mu$  longo.

Habitat in caulibus Cupressi tempore tumores fusiformes faciens.

Specimens examined. On *Cupressus pygmaea* (Lemm.) Sarg. California. Mendocino Co.; E of Noyo, *Peterson 64-21*; *Peterson 641-21*; *Peterson 65-120* (BPI-holotype, PUR, UC, Forest Service Herb., Logan); E of Anchor Bay, *Peterson 64-33*. On *Cupressus arizonica* var. *montana* (Wiggins) Little: Baja California: Campo de Viejas between Vallecitos and La Encantada, Sierra de San Pedro Martir, *Peterson 65-30*.

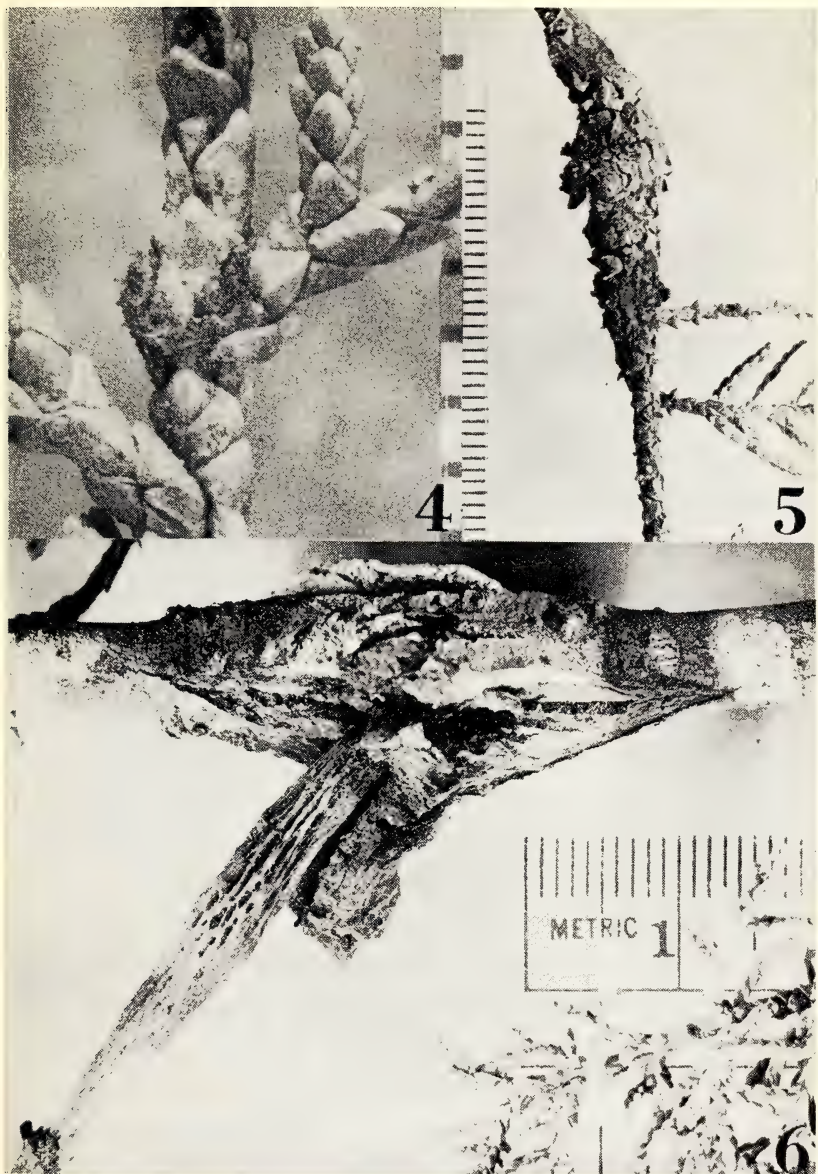
Although *U. cupressicola* is presumably related to *Gymnosporangium*, careful search failed to reveal any sure teliospores. Urediniospores from both northern California and Baja California germinate to produce long tubes, typically with several short, near-apical branches (fig. 1). Average dimensions of 50-spore samples in water from the five collections, in the order listed above, were  $22.8 \times 25.8$ ,  $22.4 \times 25.4$ ,  $22.6 \times 25.7$ ,  $22.9 \times 25.6$ , and  $23.2 \times 28.2$   $\mu$ . These are remarkably similar except for the last, which was from Mexico. Somewhat distinctive dimensions might well be expected for a collection from a different cypress in a different ecologic situation at a distance of 700 miles from the other collections, and seem not to warrant taxonomic recognition in the absence of additional evidence. The intersextile range of dimensions (the largest and smallest one-sixth of the 250 measured spores having been omitted) is narrow,  $22-24 \times 24-28$   $\mu$ .

These urediniospores, except for their pedicels, seem to be indistinguishable from aeciospores of *Gymnosporangium* in general, although



FIGS. 1-3. *Uredo cupressicola* urediniospores; 1, with typical germ tubes after 10 hours at 18° C. on 2% water agar, from type specimen,  $\times 310$ ; 2, including two spores that arose from a single pedicel, from type specimen,  $\times 650$ ; 3, spores from a single stalk separated by a length of pedicel, from Baja California specimen,  $\times 650$ .





FIGS. 4-6. *Uredo cupressicola* on *Cupressus pygmaea* from Noyo, California, scale in millimeters: 4, uredinium between leaves on two-year-old stem; 5, fusiform gall with uredinia near both ends; 6, dead primary gall with pitted xylem exposed and larger, live secondary gall.

not precisely like the aeciospores of any one species. Urediniospores are occasionally borne in tandem on a single pedicel and then appear somewhat like teliospores (fig. 2) but with scattered germ pores and almost no modification of the separate walls along their common border. The two spores of such pairs cannot easily be teased apart; in fact they seem more firmly joined than are the two cells of teliospores of *G. clavariiforme* (Pers.) DC. The spores from a single stalk rarely are separated by a length of pedicel (fig. 3). Eriksson (1919) pictures teliospores of *G. tremelloides* Hartig with separable cells that are similar to the paired spores of *U. cupressicola*. Perhaps the similarity suggests a homology between teliospores and paired urediniospores.

Uredinia of *U. cupressicola* first appear between the scale leaves of young twigs (2-year-old twigs being the youngest seen) without perceptible hypertrophy (fig. 4). Fusiform swellings (fig. 5) that result largely from increases in xylem tissue are evident on twigs 4 years old and older. The xylem surface becomes pitted or irregular as the bark dies (fig. 6). Cankers usually kill the twigs within a few years but occasionally occur on branches up to 25 years old. Probably older infections resulted from invasion by the fungus from secondary branches into stems already too large to be killed quickly.

*Uredo cupressicola* was not abundant in any of the three areas where it was studied although a few trees bore hundreds of infections. At Noyo, infections were found on twigs from 2 to about 10 years old; at Anchor Bay, only infections older than 10 years were found; and in Baja California, infections were found on twigs only 6 to 8 years old (more than 95% of these had already been killed). Old galls also occur on *Cupressus pygmaea* inland from the towns of Caspar and Mendocino, but the rust fungus, if present at all on those galls, had been overgrown by discomycetes.

*Gymnosporangium cupressi* Long & Goodding, Bot. Gaz. 72:39, 1921. This fungus has previously been reported on *Cupressus arizonica* Greene in two areas in Arizona (Long & Goodding, 1940). Telia scarcely distinguishable from those of *G. cupressii* are locally abundant on *Cupressus bakeri* Jeps. near Burney Springs in the Lassen National Forest, Shasta Co., California (Peterson 65-457 and 65-459). A few microscopic characteristics of the California specimens differ somewhat from Long and Goodding's description: most notably, the thick-walled teliospores occasionally have warts to 2  $\mu$  high near their apices, unmentioned for this species. But my one collection of *G. cupressi* from Arizona (62-167, from Sedona) also has teliospores with small verrucose areas. The teliospores from California are, on the average, somewhat wider than those from Arizona, and the colorless-walled spores have even thinner walls than their Arizona counterparts.

Although most common on green twigs, all stages of gall and canker development to ages greater than a century are present. The old cankers enlarge very slowly. Where infection spreads from a branch into a trunk





FIG. 7. Cankers caused by *Gymnosporangium cupressi* var. *cascadense* on *Cupressus gakeri*, near Burney Springs, Shasta Co., California. Hand-axe is 18 inches long.

already several years old, host growth just about keeps pace with fungus growth and the tree may never be girdled. Old cankers (fig. 7), not previously described for *G. cupressi* resemble the "hip cankers" of *Peridermium harknessii* on pine (Peterson, 1961) with flaring sides ("hips") of mostly uninfected reaction tissue.

Closely associated with the rust on *Cupressus* in one area were aecia on *Amelanchier pallida* Greene. About 15 bushes were heavily infected. Where *Amelanchier* grew within 1-2 meters of *Cupressus* branches, both *Amelanchier* and *Cupressus* bore hundreds or thousands of rust infections per plant. Where the two hosts were several meters apart, only light infection was found on both. In *Cupressus* stands where no *Amelanchier* was found, *G. cupressi* was lacking (e.g., south of Cypress

Camp) or was found only in cankers several decades old (e.g., in the easternmost part of the *Cupressus* stand along the road to Hat Creek). No Cupressaceae other than *C. bakeri* could be found during an intensive search covering about two acres around the heavily infected *Amelanchier*, nor in a less intensive search in a larger area. There being a very high correlation between proximity and abundance of the aecial and telial stages, and no other Cupressaceae present to complicate the picture, it seems inescapable that the fungus on *Amelanchier* is the aecial form of *G. cupressi* as this species is represented in the Burney Springs stand.

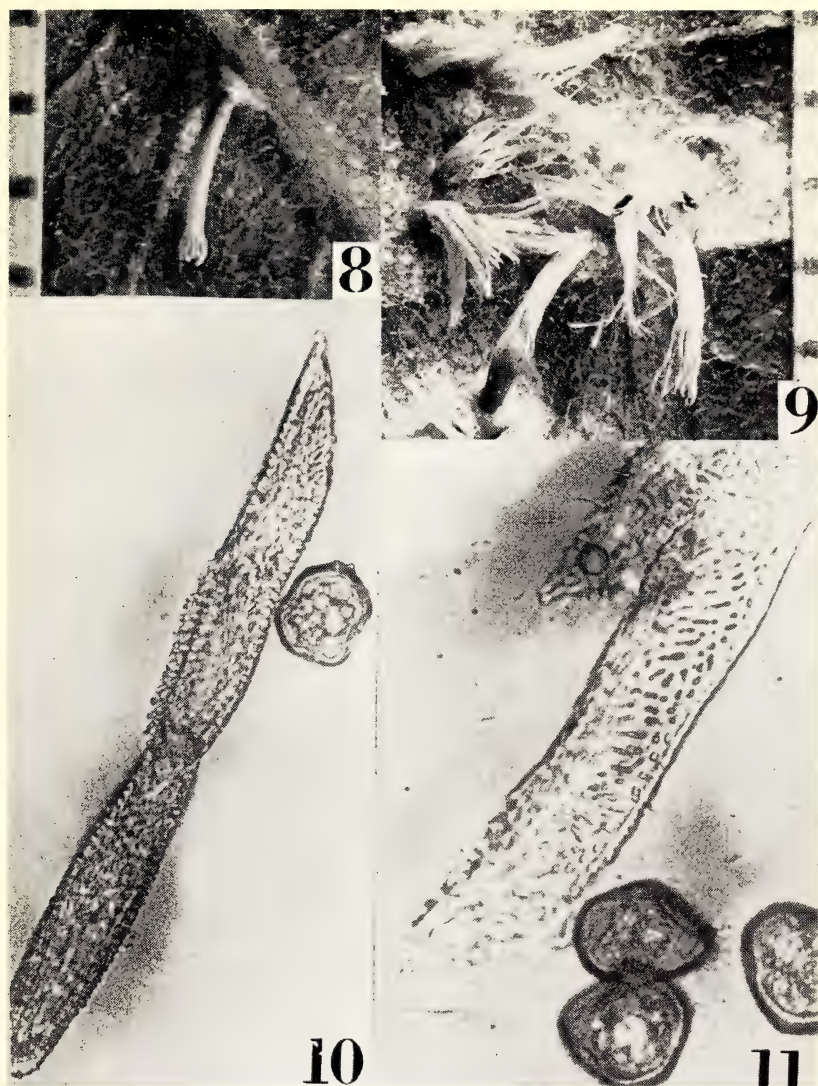
The aecia on *Amelanchier* at Burney Springs differ markedly from the aecial stage of *G. cupressi* as it is described from eastern Arizona by Long and Goodding (1940). Height of aecia, manner of dehiscence, length of peridial cells, and especially the size of aeciospores appeared, by the published description, to distinguish the two *Amelanchier* parasites. The only known Arizona collection, Goodding and Mallery 10-6-1939 (BPI-Herb. W. H. Long No. 8439), was borrowed and some of the seeming differences were easily resolved. Long's figures on aeciospore size, for instance, must have been based on immature spores, which are found at bases of aecia; measurements of mature spores from upper parts of the aecia do not even overlap Long's measurements but match closely those of the California specimen. Some other differences between the two fungi were real. Because characteristics of the sporophytes from Arizona and California are so similar, and because in the aecial stage these two fungi, although distinct, are more similar to one another than to other *Gymnosporangia*, they can best be regarded as varieties of a single species, described as follows.

*Gymnosporangium cupressi* var. *cupressi*. Spermogonia epiphyllous, conspicuous, on discolored spots. Aecia hypophyllous, on thickened and discolored spots, cylindric, to 6 mm. high by 0.2-0.3 mm. in diameter. Dehiscent along sides and from apex by longitudinal slits. Peridial cells not hygroscopic, linear to lanceolate or oblong in face view,  $11-28 \times 54-93 \mu$ ; in side view roughly oblique parallelograms in outline, 20-31  $\mu$  thick; inner and side walls 4-11  $\mu$  thick, verrucose- or tuberculate-rugose; outer walls 1-2  $\mu$  thick, smooth. Aeciospores angular to globoid,  $19-27 \times 22-33 \mu$ , walls 2-3  $\mu$  thick, cinnamon brown, very minutely and closely verrucose; germ pores conspicuous, 5-6, scattered.

Telia as described by Long and Goodding (1940), or some teliospores with apical warts. On *Amelanchier utahensis* Koehne *sensu lato* and *Cupressus arizonica* Greene var. *arizonica* and var. *glabra* (Sudw.) Little in Arizona.

*Gymnosporangium cupressi* var. *cascadense* R. Peterson, var. nov. Ac *G. cupressi* var. *cupressi* simile, sed aeciis usque 3 mm. alt., cellulis ex medio peridio visis de fronte  $16-36 \times 54-130 \mu$ , plerumque  $85-115 \mu$  longis, visis de latere oblongis,  $17-30 \mu$  cr.; aeciospores (17-)  $21-24$  (-29)  $\times$  (22-)  $24-29$  (-33)  $\mu$  (sextantibus maximis minimisque separatim inclusis) cum poris germinationis 6-11, dispersis; teliosporiis cum





FIGS. 8-11. *Gymnosporangium cupressi* var. *cascadense* on *Amelanchier pallida*: 8, aecium showing initial apical dehiscence; 9 aecia lacerate to below the middle; 10, aeciospores and peridial cell in face view,  $\times 500$ . 11, aeciospores and peridial cell in side view,  $\times 750$ .

membranis coloratis  $25-30 \times 41-53 \mu$ , membranis  $0.8-3.0 \mu$  cr.; teliosporiis cum membranis hyalinis  $20-22 \times 43-50 \mu$ , membranis  $0.8-1.0 \mu$  cr.

On leaves of *Amelanchier pallida* (causing swellings to 0.6 mm. high and necrosis) and *Cupressus bakeri*.

Specimens examined. California. Shasta Co.: Lassen National Forest, W of Hat Cr. Ranger Station, *Peterson 65-461* (on *Amelanchier*); S of Hat Cr.-Burney Springs road and north of Cypress Camp, *Peterson 65-459* (BPI-holotype, PUR, UC, Forest Service Herb., Logan (on *Cupressus*); along Hat Cr.-Burney Springs road, 8 miles W of Ranger Station, *Peterson 65-457* (on *Cupressus*).

Average dimensions of 150 aeciospores of var. *cascadense* mounted in water were  $22.4 \times 26.5 \mu$ , versus  $22.7 \times 25.9 \mu$  for 50 spores of var. *cupressi*. Germ pores are conspicuous in aeciospores of both varieties, and their number provides the best single characteristic by which the varieties may be distinguished: 5-6 in var. *cupressi* and 6-11 (usually 7-8 in var. *cascadense*. Other distinguishing characteristics, such as heights of aecia and lengths of peridial cells, will be less reliable at least until more specimens are available of var. *cupressi*: the Goodding and Mallery collection consists of only two aecium-bearing infections bearing a total of four overmature aecia.

Aecia of *G. cupressi* (figs. 8-9) are similar to those of *G. clavariiforme* (Pers.) DC., which was reported (as *Roestelia lacerata* Fr.) on *Amelanchier* from the Sierra Nevada of California by Harkness (1887). Unfortunately, according to Bonar, no supporting specimens are available, and no further aecial collections of *G. clavariiforme* are recorded from the state. It may be that Harkness had an early collection of *G. cupressi*, which may very well occur in *Cupressus* stands of the Sierra Nevada. Wall markings of peridial cells of the two species are distinguishable, those of *G. cupressi* (figs. 10-11) tend to be coarser and more ridge-like (rather than round) on the side walls than those of *G. clavariiforme*. Peridial cells of the latter species also have elongate markings, but mainly on inside walls. Probably the most clearcut distinction is in the aeciospore ornamentation, which is much finer in *G. cupressi* than in *G. clavariiforme*; in fact most spores of the former appear smooth in silhouette except under very high magnification. The warts of *G. cupressi* aeciospores are generally less than  $0.2 \mu$  high and occur at an average density (excluding germ pore areas) of 1.5-2 per square micron; those of *G. clavariiforme* are more than  $0.2 \mu$  high and occur at an average density of 0.5-0.7 per square micron.

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## TWO NEW ERIOGONUMS FROM BAJA CALIFORNIA, MEXICO

JAMES L. REVEAL AND CRAIG A. HANSON

During recent herbarium studies on *Eriogonum* conducted independently by both authors we discovered two undescribed buckwheats collected by H. S. Gentry from the Sierra Vizcaino region of west-central Baja California, Mexico. They are as follows:

**Eriogonum encelioides** Reveal & Hanson, spec. nov. Frutex basi valde ramosus, 3–5 dm altus, lanatus; foliis basalibus, oblongis vel ovatis, (2–)2.5–4.5(–5) cm longis, 1.5–2.5(–3) cm latis; inflorescentia ramemosa cum bracteis 2–4 mm longis; involucris turbinato-cylindricis, 2–3.5 mm longis, 1.5–2 mm latis; perianthiis (2.5–)3–3.5 mm longis, albis, extus glabris, intus pilosis, segmentis oblongis vel ellipticis, (2.5–)3–3.5 (–4) mm longis; staminibus exsertis, filamentis basi minute pilosis, antheris oblongis; acheniis exsertis, 4 mm longis, glabris. *E. elongato* et *E. vollmeri* affinis sed habitu frutescente differt et *E. wrightii* var. *pringlei* et var. *nodoso* foliis latoribus differt.

Low spreading loosely branched perennial shrubs 3–5 dm high with the ascending dichotomous branches densely lanate-tomentose throughout, leafy in the lower portions, sheathing up the stem 1–5 cm; leaves oblong to ovate, the blades (2–)2.5–4.5(–5) cm long, 1.5–2.5(–3) cm wide, leathery, the apices acute to obtuse, the bases acute to truncate, densely white-lanate on both surfaces, prominently veined, the petioles long, 1–2 cm long, semi-terete, lanate, tapering to short bases, these extending completely, or nearly so, around the stem; inflorescence of several erect slender primary branches, with several shorter lateral spreading secondary branches each with 3–15 racemose involucre-bearing nodes, the internodes up to 15 cm long, these also often with several shorter tertiary branches with 3–8 nodes, these internodes up to 5 cm long; bracts triangular-deltoid, 2–4 mm long, brownish, thinly lanate, the acute linear apices usually curving inwardly, ternate, connate; involucre turbinato-cylindrical, 2–3.5 mm long, 1.5–2 mm wide, densely lanate between the 5 distinct, sparsely brownish lanate ribs without, glabrous within except for the lobes, the bractlets linear-oblong, numerous, 2–3 mm long, 0.2 mm wide, hirsutulous with long marginal cells, the pedicels glabrous, 2.5–4 mm long, stoutish, 8–15-flowered; perianth (2.5–)3–3.5(–4) mm long at anthesis, white to brownish-white with a reddish-brown midrib, glabrous without, pilose within on the wide upper part of the segments, the calyx-segments similar, oblong to narrowly elliptical, 3–4 mm long, 1–1.2 mm wide, the apices rounded, the bases tapering, united only at the base; stamens exserted, the filaments up to 4 mm long, pilose at the bases, the anthers oblong, 0.6–0.8 mm long, 0.4 mm wide, white to pink; perianth 4 mm long in fruit; achenes exserted, 4 mm long, ovate, the bases tapering to a point, the apices tapering to 3-angled beaks.



Type. Coarse rocky soil in a mountain pass at Portozuelo near Aguaje San Jose, Sierra Vizcaino, Baja California, Mexico, 13 Nov. 1947, *Gentry* 7777 (UC-holotype, AHFH, DS, SD, US).

Additional specimens examined. At Portozuelo near Aguaje San Jose, *Gentry* 7777a (AHFH, DS, UC) 7777b (AHFH, SD, UC, US).

*Eriogonum encelioides* is a member of the subgenus *Eucycla* (Nutt.) Kuntze and is a member of an undescribed subsection of the section *Racemosa* Rydb. which includes *E. elongatum* Benth. and *E. vollmeri* Wiggins. The species name was suggested by Gentry's label which noted that the plant resembled a "low spreading Encelia-like bush . . ."

This new species is related to *E. elongatum* and *E. vollmeri*, but it differs from both in being more woody and shrubby with a decidedly more spreading branched paniculate inflorescence with the involucre race-mosely arranged on secondary and tertiary branches. The involucre of the new species are shorter (2–3.5 mm long) than those of *E. elongatum* and *E. vollmeri* (5–7 mm long), but the flowers of *E. encelioides* are larger (3–3.5(–4) mm long) than those of its two relatives (less than 3.5 mm long). The leaf characters vary in *E. elongatum*, but the leaves are never as wide as in *E. encelioides* and *E. vollmeri*, and these two species differ mainly in that the petiole of *E. encelioides* is less than 2 cm long whereas *E. vollmeri* has petioles rarely under 3 cm long.

From *E. wrightii* Torr. ex Benth. the new species differs in having much larger, oblong to ovate leaves rather than the lance-elliptic leaves of *E. wrightii* var. *pringlei* (Coul. & Fish.) Reveal and var. *nodosum* (Small) Reveal which the new species approaches in its woody habit.

*ERIOGONUM PONDII* Greene, *Pittonia* 1:267. 1889. Low densely branched shrubs 2.5–5 dm high with several ascending di- or trichotomous leafy, lanate branches; leaves 3–25 mm long, spatulate or elliptic to obovate, the blades 2–20 mm long, 2–9 mm wide, leathery, the apices acute to rounded, gradually narrowing to short petioles 1–5 mm long, densely tomentose above and below, often less so above, present the whole length of the stem except on the short flowering branches; inflorescence of a few spreading branches, the flowering stems up to 1 cm long; bracts lacking; involucre campanulate, 3–5 mm long, 3–4.5 mm wide, densely lanate between the 5 distinct lanate ribs, the bractlets short, 1–2 mm long, linear, short-hirsutulous, the pedicels glabrous, 3–7 mm long, 10–20-flowered; perianth 2–6 mm long, white to pink, calyx-segments dissimilar, the outer whorl orbicular, 2.5–5 mm long and wide, the inner whorl spatulate, 2–6 mm long, 1–2.5 mm wide, glabrous without, minutely glandular-puberulent within toward the base of each segment; stamens included, the filaments 1–4 mm long, densely yellowish-white pilose at the bases, the anthers oblong, 0.3–0.5 mm long; achenes brown, 2.5–4 mm long, ovate, the apices tapering to 3-angled beaks.

*ERIOGONUM PONDII* var. *PONDII*. Shrubs 2–3 dm high; leaves densely tomentose on both surfaces, less than 12 mm long; perianth pink, 2.5–3 mm long, the outer whorl of segments up to 3 mm long and wide, the



inner whorl of segments up to 3.5 mm long and 1.5 mm wide; involucre 2.5–3.5 mm long and wide, the pedicels up to 5 mm long, the bractlets 1.3–2 mm long.

Type. Cedros I., Baja California, Mexico, Dec. 1888–Feb. 1889, *C. F. Pond 83* (US).

Additional specimens examined. Cedros I.: *Anthony 310A* (GH, US); *Haines & Hale s.n.* (NY, UC, US, UTC); *Moran 10599* (DS, SD, US); *Palmer 706* (GH, NY, US); *Rose 16113* (GH, US); *Rose 16114* (US). Natividad I.: *Moran 10803* (GH, SD, US). San Bartolome Bay: *Howell 10659a, 10708* (CAS, GH); *Mason 1960* (GH, UC, US); *Pond s.n.* (US); *Rose 16203* (US).

*ERIOGONUM PONDII* var. *gentryi* Reveal & Hanson, var. nov. A var. *pondii* differt planta 3–5 dm alta; foliis 10–25 mm longis; involucriis 4.5–5 mm longis et 4–4.5 mm latis, pedicellis ad 7 mm longis, bracteolis 1–1.3 mm longis; perianthis albis, 4.5–6 mm longis, exterioribus segmentis ad 5 mm longis et latis, interioribus segmentis ad 6 mm longis et 2.5 mm latis.

Shrubs 3–5 dm high; leaves densely tomentose below, less so above, 1–2.5 cm long; involucre 4.5–5 mm long, 4–4.5 mm wide, the pedicels up to 7 mm long, the bractlets 1–1.3 mm long; perianth white, 4.5–6 mm long, the outer whorl of segments up to 5 mm long and wide, the inner whorl of segments up to 6 mm long and 2.5 mm wide.

Type. Near eastern bajada in gravelly arroyo, Sierra Calvario, south-eastern flank of the Sierra Vizcaino, Vizcaino Desert, Baja California, Mexico, 10–15 Mar. 1947, *Gentry 7510* (UC-holotype, AHFH, DS, SD).

Additional specimens examined. Near Cerro Tordillo, Vizcaino Desert, *Gentry 7441* (AHFH, DS, SD, UC).

This species belongs to the subgenus *Eucycla* (Nutt.) Kuntze and is a member of an undescribed section.

Variety *gentryi* is an inland form apparently well isolated from var. *pondii* which grows along the immediate coast and adjacent islands.

It is a pleasure for us to name this variety in honor of Dr. Howard S. Gentry of the Crop Research Division, U.S. Department of Agriculture, and an authority on *Yucca* and *Agave*, who not only collected the plants, but gave us additional information on both.

We are grateful to the various curators who kindly allowed us the use of their herbarium material or facilities. We wish to thank C. V. Morton for his help with the Latin diagnoses. The senior author wishes to thank the Smithsonian Institution and the U.S. National Herbarium which sponsored his Predoctoral Internship program in Washington, D.C., from September 1966 to February 1967 where this study was concluded.

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## REVIEWS

*Index to European Taxonomic Literature for 1965.* Compiled by R. K. Brummitt. 166 pp. Published under the auspices of the Flora Europaea Organization by the International Bureau for Plant Taxonomy and Nomenclature, Utrecht, 1966, as *Regnum Vegetabile* Vol. 45. About \$6.33; members of IAPT \$3.00.

The importance of an annual index to botanical literature for an area the size of Europe can now be appreciated with this surprisingly vast first volume, described by the compiler as "experimental." The geographical coverage is extended from that of the *Flora Europaea* project to include also the Mediterranean margin of Africa down to the Sahara, and eastward through Jordan and Syria to the Caucasus. This is a handy guide to the periodic literature on north temperate plants and it goes quite far beyond the limitations of a strictly taxonomic index. It is patterned after and geographically complements the *A. E. T. F. A. T. Index* (Association pour l'Etude Taxonomique de la Flore d'Afrique Tropicale) which has appeared since 1953, covering similar information for Tropical and Southern Africa.

The table of contents directs one to the following categories: General; Biography; Bibliography; Herbaria, Botanical Institutes, Botanic Gardens; Phytogeography; Floras, Floristic Studies; Chromosome Surveys—these taking up 20 pages. The next 114 pages include the references to Pteridophyta, Gymnospermae, and Angiospermae. The angiosperms are arranged alphabetically by family and then by genus. The appendix, 15 pages contributed by I. K. Ferguson, is a listing of the 408 abbreviated journal names cited in the *Index* followed by the complete title—and even better coverage is promised for the future!

Most Americans, I should think, would believe that the plants of Europe are quite well known, at least in comparison to other parts of the world, and will be startled to find that this *Index* lists 1009 new names published in 1965 for Europe and adjacent areas. This includes five new family names, six new genera, and 263 new specific names. New names are presented in bold face if they are judged to be simultaneously validly published and legitimate. Other names appear in ordinary roman type. The introduction points out that some of the names may not be legitimate or valid for reasons not readily apparent in the place cited since it was not possible to confirm all details for this essentially one man production.

The format is good and easy to use and it would not seem possible to create a volume of this size and scope without the introduction of some judgment. This is seen in the selection of family names. The use of Compositae, Cruciferae, Gramineae, Labiatae, and Leguminosae shows pleasing conservatism. Names such as Buddlejaceae, Cleomaceae, Leonticeae, and Visaceae remind one that systematic arrangement of even some common plants still is in a state of confusion with many interesting and unresolved problems. Use of the name "Capparidaceae" is a contradiction of the Code since only the name Capparaceae is conserved. The name Cleomaceae shows the consequences of splitting traditional groups since the genus *Polanisia* (herbaceous and intimately allied to *Cleome*) is indexed under "Capparidaceae" while *Cleome* appears only under Cleomaceae. There are cross references and it is quite clear that the purpose of this *Index* never was to arbitrate taxonomic controversy. The placement of *Ebenus* under Ebenaceae and *Eremurus* under Gramineae are rare but quite unimportant inadvertences.

Selected indices for specific fields or areas make very convenient reference resources for special audiences and there is the advantage that much information can be left out resulting in more rapid publication of the *Index*. This *Index* for Europe, undoubtedly stimulated by the *Flora Europaea* project, also will be useful to Americans. A similar kind of index would be desirable for North America now that a *Flora North America* project is underway. As in Europe and Great Britain, there is a limit to the number of institutions which receive enough journals with botanical inclusions. A world index to botanical literature, to include also other topics ap-

plicable to taxonomy, already is a vacant necessity, and its realization might bring botanists closer to the much sought after stability that they all want. With the combined efforts of I. A. P. T., A. S. P. T., and other large groups of botanists it would seem feasible to begin an annual review of the literature on systematic botany for rapid publication. The *Bibliography of Agriculture* comes closest to serving this need.

In this age of mechanical enlightenment it is too much to expect narrowly supported one-man or one-institution productions to continue indefinitely to turn out reference tools such as the *Gray Herbarium Card Index*, *Index Kewensis*, *Card Index to American Botanical Literature*, *Index Nominum Genericorum*, or *Index to Plant Chromosome Numbers*. There also is a need for the continuation of completed works such as Langman's *A selected guide to the literature on the flowering plants of Mexico*, Merrill & Walker's *A bibliography of eastern Asiatic botany*, Pfeifer's *Nomenclator*, Rehder's *Bibliography of cultivated trees and shrubs*, to name only a few. These noble contributions are of lasting international importance and should receive international support for continuance. With such a fine example at hand it may seem unreasonable to ask for even more but I believe that Brummitt's *Index* reaffirms the need for an annual world index to botanical literature and it would be most useful to me if it were in card form or rapidly available printouts. The beginning of such a long term enterprise could be one of the botanical goals of the forthcoming International Biological Years and mechanical sorting methods could satisfy almost everyone with just the right references.—WALLACE R. ERNST, Smithsonian Institution, Washington, D.C.

*Botanical Latin*. By WILLIAM T. STEARN. xiv + 566 pp., many illustrations. Hafner Publishing Company, 31 East 10th Street, New York, N. Y. 10003. 1966. \$16.75.

William T. Stearn's admirable work is not only a guide to the writing and deciphering of Latin descriptions and diagnoses but a valuable compendium of immensely varied botanical information as well. As such, it has earned an indispensable place on every systematic botanist's workshelf. Here is no mere "dry as dust" exposition of paradigms, conjugations, rules of syntax and all the other bases for correct Latin writing but a most entertainingly presented and eminently readable work replete with many topics of absorbing general interest. Among such, for example, is the history of the development of botanical Latin, both pre- and post-Linnaean, as an autonomous and fairly simplified and conventionalized form of expression based, however tenuously, on classical Latin. Another is an exposition of the influence of ancient and classical authors, culminating in the works of Ray and Tournefort, in supplying a concise descriptive vocabulary which was considerably elaborated and crystalized by Linnaeus — to mention only two of the many topics so felicitously touched upon. [One is indirectly admonished as to pitfalls to be avoided by the author's citation of somewhat amusing examples of bad "modern" botanical Latin.] Even as a reference compendium for such diverse matters as latinized geographical names of cities and regions, the formation of epithets based on the names of persons, standard botanical symbols and abbreviations, well illustrated examples of descriptive adjectives, a list of Latin color terms based on Lindley's and J. W. Jackson's works, pronunciation of botanical terms — again choosing at random subjects dealt with — Stearn's excellent and often discursive though nicely organized labor of love will readily recommend itself as a work the systematic botanical worker will feel he cannot afford to deny himself.

The book is divided into four main sections: Introductory chapters on the historical development of botanical Latin and a preliminary chapter on "How to Use This Book"; Grammar; Syntax and Other Matters; and Vocabulary and Bibliography.



In the chapter on syntax, numerous approved examples of diagnoses and descriptions of plants from all the main groups, from Algae, Fungi and Lichens to the Angiosperms, are proffered as models to emulate.

An unusual feature is the extensive vocabulary which devotes some 170 pages to a listing of both Latin-English and English-Latin terms under a single caption. A section which has already proved immensely instructive to the present reviewer is a chapter on the use of Greek words in botanical Latin which contains much information under such subheadings as the indebtedness of botanical Latin to Greek, the nature of word-endings, the gender of Greek nouns and adjectives, the formation of compounds, consonant-changes, a trans-literation of the Greek alphabet, and a vocabulary of Greek word-elements.

It is truly amazing how much information has been compressed by the author into something like 550 pages. A perusal of these pages is very likely to fill in a number of gaps in one's knowledge of classical botany and, more than incidentally, to provide several hours of most pleasurable reading. And it DOES provide, within the confines of a single cover, perhaps for the first time in English at least, all one needs to know about writing, and to a slightly lesser extent, about deciphering Latin botanical descriptions.

Regrettable, in the first printing at least, is the misspelling of the author's name on the spine of the work. — RIMO BACIGALUPI, Jepson Herbarium, Dept. of Botany, University of California, Berkeley.

*The Grasses of North Carolina.* By H. L. BLOMQUIST. Duke University Press, Durham, N. C., vi + 276 pp. 1948. \$7.50. *Grasses of the Texas Coastal Bend.* By FRANK W. GOULD and THADIS W. BOX. Texas A & M University Press, College Station, Texas. 189 pp. 1965. \$3.25.

In a large and taxonomically difficult family such as the Gramineae, regional treatments are especially valuable in that they treat fewer species than a manual such as Chase (Man. Gr. U. S., rev. ed., 1950) where identification may become difficult simply because of the sheer weight of numbers of species that must be dealt with. Thus, the appearance of state and local grass floras, such as the two reviewed here, is welcome for they serve to make identification easier, thereby stimulating interest in the family and providing more information of grass species and their distribution.

The keys, generic order and, to a lesser extent, descriptions, in Blomquist's treatment of North Carolina grasses all follow quite closely the pattern of Chase. As such the keys have time proven advantages (and errors) and will "run" reasonably well for most genera. A few genera, such as *Aegilops*, will not key in either Chase or Blomquist. The line drawings are clear and, except in a few cases where they have been too reduced, will be valuable in checking identifications. The accompanying detailed distribution maps, one for each species, clearly show the need for additional collections in North Carolina. Notes on the economic importance of various species are interesting and valuable. The chapter on distribution of grasses in North Carolina will be helpful both to the floristic collector and the monographer.

Gould and Box's *Grasses of the Texas Coastal Bend* has been given a new and fresh approach throughout, including keys, descriptions and illustrations. The keys are well written and make use of characters that are relatively easily seen. Even sexual dimorphic species such as *Buchloe dactyloides* may be keyed on the basis of either male or female plants. Notes on geographic distribution, ecological relationships, economic importance as well as a description are provided for each species. Many of the descriptions are too short and general to be of value in checking identifications but in most cases a good illustration is provided. — DENNIS ANDERSON, Division of Biological Sciences, Humboldt State College, Arcata, California



*Supplement to Smith's Marine Algae of the Monterey Peninsula.* By GEORGE J. HOLLENBERG and ISABELLA A. ABBOTT. Illustrated. Stanford University Press, Stanford, California. 1966. ix + 130 pp. \$3.50.

As the title indicates this book is a supplement to G. M. Smith's volume on the Monterey algae published in 1944. Because both authors have studied the Monterey algal flora extensively during the past twenty years they are well qualified to treat this subject.

The supplement essentially serves four purposes: to add 55 species to the flora, to update the nomenclature where necessary, to include revisions of descriptions of species or other taxa and revisions of keys, and finally to add new information on distribution, life histories, etc. The format of the supplement is closely similar to that of the original work by Smith. Continuity is carefully maintained through duplication of style, method of treatment, literature and taxonomic citations, and typography. Each entry is cross referenced to pages of the main volume by a system of marginal symbols.

Two departures from the coverage and format of the main work will prove most helpful. First, the range of coverage has been extended, both north and south along the peninsula. Second, all new illustrations are included as text figures with each entry rather than in plates segregated from the text. This simplifies usage considerably.

The authors' failure to revise the main generic key to include the newly recorded genera is unfortunate, however. Because of this, students often will find it necessary to cross-check the supplement when identifying specimens to genus—a very time consuming process.

The illustrations are of a quality in keeping with those in Smith. Identification of various foliose species of the Cryptonemiales has been troublesome to many students; the inclusion of illustrations of thallus cross sections will be very helpful.

*Lobocolax*, previously considered to be a parasite on *Prionitis*, is excluded from the flora because the authors regard these structures as bacterial galls. This may be true but until definitive experimental evidence is available concerning their origin and development the authors' conclusion must be accepted with reservations.

Three informational errors, although of minor significance, should be pointed out. The illustration (p. 116) said to be of *Pterosiphonia gracilis* Kylin actually appears to be of *P. dendroidea* (Montagne) Falkenberg. Comparison with an illustration of the type specimen of *P. gracilis* (Kylin, H. 1925. The marine red algae in the vicinity of Friday Harbor, Wash. Lunds Univ. Årsskr. N.F. Avd. 2. 21:1-87) will indicate clearly the distinction. An error in Smith's book also should be pointed out at this time. The gland cells of *Antithamnion subulatum* (Harvey) J. Agardh are borne on a single branch cell (see Kylin, 1925) and not on two adjacent branch cells as illustrated in plate 78, figure 3 of Smith. This mistake could lead to misidentification because the manner of gland cell support is an important taxonomic criterion for some species of *Antithamnion*. The Pacific coast distribution for *Platysiphonia clevelandii* (Farlow) Papenfuss is much greater than indicated by the authors; Scagel (1957. An annotated list of the marine algae of British Columbia and northern Washington. Nat. Mus. Canada. Bull. no. 150) records *P. clevelandii* for northern Washington.

The supplement has very few shortcomings and will prove to be a most useful and important addition to knowledge of the local marine algae. The authors are to be commended for a job well done.—JOHN A. WEST, Department of Botany, University of California, Berkeley

*An Annotated Bibliography of Mexican Ferns.* By GEORGE NEVILLE JONES. xxxiii + 297 pp. University of Illinois Press, Urbana and London, 1966. \$5.00.

This volume is a welcome addition to the literature dealing with the flora of our sister republic and is a convenient supplement to Ida K. Langman's recent *A Selected Guide to the Literature on the Flowering Plants of Mexico* (University of Pennsylvania Press, 1964). While a certain amount of overlap between the two publications is to be expected, as they both cite a number of general works pertaining to the Mexican flora, this overlap does not appear to be excessive.

Following a short Introduction and a list of Abbreviations of Periodicals Cited is the meat of Jones' book, 237 pages of Authors and Titles, arranged alphabetically. Comments on each publication are short and to the point: Mexican taxa mentioned are often listed, along with any pertinent notes on the nature of the publication and the information contained therein. The author uses the term "ferns" broadly, including both the true ferns and the so-called "fern allies" as well. He covers not only publications dealing directly with Mexico, but also many in which plants that range into Mexico are discussed. While the bibliography is slanted toward taxonomy and phytogeography, other disciplines are not slighted. Finding Indexes (pp. 238-282) are included under four categories: General [with subcategories of Bibliographies; Collections, Excursions, Expeditions, Explorations; Economic Botany, Horticulture and Botanical Gardens, Medicinal Plants, Useful Ferns, Symbolic Uses of Ferns, Folklore; Geographical Distribution, Phytogeography (or Biogeography), Floristics; Herbaria; Annotated Catalogues, Lists and Enumerations; Manuals, Floras, Monographs, Revisions, Keys; Nomenclators, Nomenclature, Indexes, Illustrations, Gazetteers; Vegetation: Ecology; and Morphology], Geographical Index (arranged by states), Biographical Index (containing information on and references to authors cited), and Systematic Index (arranged by genus). Truly something for everyone!

The Finding Indexes are followed by a short Supplement listing a few publications and additional comments apparently compiled after the book had gone to press. Included here are only two entries published since 1962, the date through which the bibliography is intended to cover. Lastly, there is an Index of Personal Names, not including names mentioned only in the Finding Indexes.

Although this is not nearly so exhausting a bibliography for the ferns as Mrs. Langman has provided for the flowering plants, it is not to be criticized for its omission of obscure Mexican references unavailable to the author. The latter will be available for a work of this kind only when someone is willing to scour the libraries of Mexico as did Mrs. Langman.

This bibliography will prove useful not only to those interested in Mexican ferns, but also to anyone intrigued either by Mexico's bountiful flora, or by pteridophytes in general. The type, while not the most aesthetically appealing, being reproduced through photo-offset from the pica of the typed original, undoubtedly has held down the price of the book to a reasonable sum.—DUNCAN M. PORTER, Dudley Herbarium, Stanford University.

## NOTES AND NEWS

THE GENUS *KICKXIA* IN OREGON.—*Kickxia spuria* (L.) Dumort. apparently has not been reported for Oregon although it was found in the southwestern portion of the state as early as 1948 (Jackson Co., *Jossey s.n.*, OSC). The increasing frequency of its collection would seem to indicate that this European species is now well established in at least Jackson, Josephine, and Douglas counties, and it has been found as far north as Marion Co.

*Kickxia elatine* (L.) Dumort. was introduced earlier and is more wide-spread in Oregon than has previously been recorded (C. L. Hitchcock et al., *Vasc. Pl. Pacif. N. W.* 4:333. 1959; R. Ornduff, *Leaf. West. Bot.* 9:224. 1962). These two publications cite reports from Washington Co. and Multnomah Co. Specimens in the herbaria of Oregon State University (OSC) and University of Oregon (ORE) date back to 1934 and indicate a range for the species throughout western Oregon (Washington and Multnomah counties to Coos, Josephine, and Jackson counties).

I am grateful to Kenton L. Chambers and Leroy Detling for assistance in the preparation of this report.—LA REA J. DENNIS, Department of Botany and Plant Pathology, Oregon State University, Corvallis.

**CALAMAGROSTIS RUBESCENS ON SANTA CRUZ ISLAND, CALIFORNIA.**—The intensive program of field work being carried out by the Santa Barbara Botanic Garden has resulted in one of the most notable additions to the flora of the California Channel Islands obtained in recent years—*Calamagrostis rubescens* Buckl. This tall attractive rhizomatous grass was collected on Santa Cruz Island, July 22, 1960, *Blakley & Muller 3726* (SBBG, DS). It grew on sandy clay soil, and was scattered in sunny spots of the pine forest on the ridge between the north and south forks of Cañon Cervada, elevation 1300 feet. It is not surprising that the species had not been collected in this relatively inaccessible locality previously, especially considering that it was just coming into bloom in late July. This record not only represents a range extension southward from maritime San Luis Obispo Co. (*Leaf. West. Bot.* 10:78. 1964), but it is the first report of any species of *Calamagrostis* from the California Channel Islands. As such, it fits in well with the other plants of the northern tier of islands which reach the mainland only at some distance to the north of these islands.—PETER H. RAVEN, Stanford University.

**TWO NEW ADDITIONS TO THE FLORA OF MONTANA.**—*Grindelia howellii* Steyermark was first collected by L. F. Henderson (2791, GH-type, RM, US) on dry arid bluff tops, St. Maries River, Kootenai Co., Idaho, and has been known only from the type collection. Recent collections in 1966 (*Woodland 827, 906*, MONTU, DS) of *G. howellii* have been made in Missoula Co. at Placid Lake, in dry roadside where the road bridge crosses the stream outlet. Reconnaissance throughout the region has revealed only the presence of this Placid Lake population. *G. howellii* differs from the more common *G. nana* Nutt. and *G. squarrosa* (Pursh) Dunal in having a glandular and somewhat villous stem at least in the inflorescence, leaf margins which are dentate to denticulate or entire, and the middle and lower leaves are clasping and not narrowed at the base. The stems of *G. nana* and *G. squarrosa* are essentially glabrous, and the leaves are scarcely clasping and more narrowed to the base. The identification of *G. howellii* was confirmed by Arthur Cronquist.

*Saussurea americana* Eaton has been known in the Pacific Northwest only as far east as central and northern Idaho. Booth and Wright (*Flora of Montana*, Part II, 1966) do not report the genus as occurring in Montana. Four different collections and three county records are now available for western Montana: Lincoln Co.; Leigh Lake, Cabinet Mts. Wild Area, 5500 ft., *Woodland 854* (MONTU, DS). Mineral Co.; near Hoodo Pass, *Stickney 1401* (Intermountain Forest & Range Experiment Station Herbarium, Missoula). Ravalli Co.; above big bend of Fred Burr Canyon 6000 ft., *McDonald 1797* (IFRES); Lost Horse Creek, Bitterroot Mts., 5400 ft., *Thomas 11365* (MONTU, DS). All collections were made in early August.—DENNIS W. WOODLAND, Department of Botany, University of Montana, Missoula.



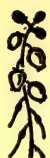
FLORA NORTH AMERICA.—The newly formed Editorial Committee of *Flora North America*, as the project will be called, met for the first time on January 30, 1967, at the Smithsonian Institution in Washington, D.C. This three-day meeting, convened by William L. Stern (Smithsonian), Chairman *pro tem.* of the Steering Committee, was attended by all members of the Editorial Committee: Peter H. Raven, Chairman, Stanford University; Stanwyn G. Shetler, Secretary, Smithsonian Institution; John H. Beaman, Michigan State University; Kenton L. Chambers, Oregon State University; Robert Kral, Vanderbilt University; Walter H. Lewis, Missouri Botanical Garden; John T. Mickel, Iowa State University; Roy L. Taylor, Canada Department of Agriculture, Ottawa; John H. Thomas, Stanford University; also attending were Robert F. Thorne (Rancho Santa Ana Botanic Garden), Chairman of the Advisory Council, and Vernon H. Heywood (University of Liverpool), Secretary of *Flora Europaea*, who served as a consultant in the discussions and gave a concluding public lecture, "*Flora Europaea*, Its Conception and History," on 1 February. The purpose of the project is to prepare a concise diagnostic manual to the vascular plants of the continental United States, Canada, and Greenland, and the Editorial Committee dealt at least in a preliminary way with a large range of questions concerning the roles of the respective committees, the functioning of the Editorial Committee and its secretariat, the solicitation of authors and advisors, and the format, arrangement, timetable, and funding for *Flora North America*. It is expected that the first 12 to 18 months will be occupied getting the project fully organized and the working procedures implemented. This will be followed by the second phase of intensive writing and editing for the first volume. Tentatively, four volumes, followed by a fifth comprising a theoretical symposium on the North American flora, are anticipated. The whole effort is expected to last 12–15 years. A full progress report on *Flora North America* will be published at an early date. The Editorial Committee will convene its next meeting at College Station, Texas, in August 1967, when the American Institute of Biological Sciences holds its annual meetings at the Agricultural and Mechanical College of Texas. The first meeting was financed by the Smithsonian Office of Systematics (Richard S. Cowan, Director).—STANWYN G. SHETLER, Smithsonian Institution, Washington, D.C.

HETERANTHERA LIMOSA IN CALIFORNIA. — In June, 1966, Donald E. Seaman (at that time, Assistant Research Botanist, University of California, Davis) noted in a rice field in Glenn County a water weed, *H. limosa* (Sw.) Willd. ("duck salad", or "mud plaitain"), of the family Pontederiaceae, which had not previously been reported in California. On June 30, we visited the area with Seaman to observe the plant and to make a large collection (*McCaskill 713* and *Tucker*, DAV).

This location is on the farm of Harvell Hansen, Sr., about three miles southwest of Codora, Glenn Co. According to Carl Wick, Butte Co. Farm Advisor, about 100 acres are infested here. We observed it in a number of individual plots between County Road U and Willow Creek, 1.2 miles south of County Road 61 ("Riz Road"). It was most abundant along the west side of several of the low levees between plots, in water 8–10 inches in depth, the leaf blades and flowering peduncles projecting above the surface. Of the plants in flower that we examined closely, most were also maturing seed in abundance. Flower color was consistently white, although it is often described in manuals as blue. Wick has subsequently reported finding a second infestation in Glenn Co. (ca. 3 miles southeast of Willows), and two in Butte Co. (one at Biggs, the other just north of Richvale).

Current manuals record *H. limosa* for the southern and midwestern states, and indicate a range extending as far west as Colorado, New Mexico, southeastern Arizona, and Sonora. Although apparently not previously reported in the literature in California, Thomas C. Fuller, California State Department of Agriculture, Sacramento, informs us that two sheets of this species, collected in Glenn Co. in 1948, are filed in the State Department of Agriculture Herbarium in Sacramento. Thus, since the plant has existed in this rice-growing area for at least eighteen years, it probably does not pose a very serious weed threat.—JOHN M. TUCKER and JUNE MCCASKILL, Department of Botany, University of California, Davis.





# MADROÑO

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# MADROÑO

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## CHECK LIST OF CALIFORNIA PTERIDOPHYTES

LAWRENCE L. KIEFER and BARBARA JOE

Those engaged in identifying California plants are well aware of the different taxonomic treatments given pteridophytes in the standard manuals and floras. These treatments are confusing, but it must be remembered that they were prepared at different times and by different people. In addition, specialists and nonspecialists alike must reckon with recent name changes, newly established populations, and occasional new records of pteridophytes not previously known from California. Thus, there is no readily available single source which can be used to ascertain the correct name or to determine the number and kinds of California pteridophytes. It follows that a check list giving information of this nature is in order and is especially needed since ferns are increasingly being used for general research and are receiving more public interest.

In this check list we have endeavored to select the most widely accepted name. So users of this check list may have a broader scope of information, we thought that it would be helpful to list after each entry the corresponding name and page on which these names may be found in three standard works. These are: *Illustrated Flora of the Pacific States*, Vol. I (1940) by LeRoy Abrams, however, the treatment of the pteridophytes was done by William R. Maxon except for the Isoetaceae which were done by Norma E. Pfeiffer; *A Manual of the Flowering Plants of California* (1925) by Willis Linn Jepson; and *A California Flora* (1959) by Philip A. Munz. Where the check list entry is absent in all three books, a reference to a bibliography or herbarium record which first reports the occurrence of the plant in California is given. All other bibliographies have been omitted. Synonymous generic names used in the three standard works are listed with cross references. Synonymous names will be found in the text following the accepted name. Plants falling into the categories of subspecies or variety are entered but forms have been omitted. Taxa deemed in need of further study or are of doubtful occurrence in California are marked with an asterisk. Many of these problem plants are being studied currently.

It is inevitable that changes will be required in this check list as the many gaps in our knowledge of California pteridophytes are filled. Until then, however, we hope that it will be helpful.

We wish to acknowledge the kind help and careful attention given to checking the manuscript by Ira L. Wiggins of Stanford University, Rolla Tryon of Harvard University, Warren H. Wagner, Jr. of the University of Michigan, Thomas R. Pray of the University of Southern California, and C. V. Morton and David B. Lellinger of the Smithsonian Institution.

## OPHIOGLOSSACEAE. Adder's-tongue Family

\*BOTRYCHIUM LUNARIA (L.) Swartz, Moonwort, Abrams, 3; Jepson, 25; Munz, 30, misinterpreted as *B. lunaria* var. *minganense* (Victorin) Dole, a variety not native to California.

\*BOTRYCHIUM MULTIFIDUM (Gmel.) Rupr. ssp. COULTERI (Underw.) Clausen, Leather Grape Fern. Abrams, not listed; Jepson, 26, as *B. silaifolium* var. *coulteri* (Underw.) Jepson; Munz, 29. Intraspecific status not recognize by W. H. Wagner (pers. comm., 1966).

\*BOTRYCHIUM MULTIFIDUM ssp. SILAIFOLIUM (Presl) Clausen. Abrams, 4, as  $\beta$  *silaifolium* Presl and *B. californicum* Underw.; Jepson, 26, as *B. silaifolium* var. *californicum* (Underw.) Jepson; Munz, 29. (Wagner, W. H., pers. comm., 1966).

BOTRYCHIUM SIMPLEX E. Hitchc., Least Grape Fern. Abrams, 3; Jepson, 25; Munz, 29.

\*BOTRYCHIUM SIMPLEX var. COMPOSITUM (Lasch) Milde. Abrams, 3, included with the species; Jepson, 25, included with the species; Munz, 29, as *B. multifidum* var. *compositum*, an erroneous combination.

\*OPHIOGLOSSUM CALIFORNICUM Prantl, California Adder's-tongue. Abrams, 2; Jepson, 25; Munz, 29. Regarded as a variety of *O. lusitanicum* L. by W. H. Wagner (pers. comm., 1966).

OPHIOGLOSSUM VULGATUM L., Adder's-tongue. Abrams, 2, but not included for California; Jepson, 25; Munz, 29.

## POLYPODIACEAE. Fern Family

ADIANTUM CAPILLUS-VENERIS L., Southern Maidenhair. Abrams, 24; Jepson, 29; Munz, 38.

ADIANTUM JORDANII C. Muell., California Maidenhair. Abrams, 24; Jepson, 29, as *A. emarginatum* D. C. Eaton; Munz, 38.

ADIANTUM PEDATUM L., Northern Maidenhair. Abrams, 24, included with *A. pedatum* var. *aleuticum* Rupr.; Jepson, 29; Munz, 38, included with *A. pedatum* var. *aleuticum*.

\*ADIANTUM PEDATUM var. ALEUTICUM Rupr. Abrams, 24; Jepson, 30; Munz, 38.

ADIANTUM  $\times$  TRACYI C. C. Hall ex Wagner. Not in California references (Wagner, W. H., Madroño 13:198, 1956).

ALEURITOPTERIS: see *Notholaena californica*.

ASPIDIUM: see *Dryopteris* and *Thelypteris*.

ASPIDOTIS: see *Cheilanthes californica*.

ASPENIUM SEPTENTRIONALE (L.) Hoffm., Forked Spleenwort. Not in California references (Howell, J. T., Base Camp Botany. Sierra Club of California. p. 3. Sept. 10, 1942; Ewan, J., Am. Fern Journ. 33:29. 1943).

ASPENIUM VESPERTINUM Maxon, Western Spleenwort. Abrams, 18; Jepson, 35, as *A. trichomanes* L. var. *vespertinum* (Maxon) Jepson; Munz, 44.

ASPENIUM VIRIDE Huds., Green Spleenwort. Abrams, 19, but not included for California; Jepson, not listed; Munz, 45.



\**ATHYRIUM ALPESTRE* (Hoppe) Rylands var. *AMERICANUM* Butters, Alpine Lady Fern. Abrams, 20, as *A. americanum* Maxon; Jepson, 29, as *Phegopteris alpestris* Hoppe var. *americanum* (Butters) Jepson; Munz, 43.

\**ATHYRIUM FILIX-FEMINA* (L.) Roth var. *CALIFORNICUM* Butters, California Lady Fern. Abrams, 19, included with the species; Jepson, 35, as var. *californicum* but some plants misinterpreted as var. *angustum* (Willd.) Farwell, a variety not native to California; Munz, 43.

\**ATHYRIUM FILIX-FEMINA* var. *SITCHENSE* Rupr. Abrams, 19, included with the species; Jepson, 35; Munz, 43.

*BLECHNUM SPICANT* (L.) J. Smith, Deer Fern. Abrams, 21, as *Struthiopteris spicant* Weiss; Jepson, 34, as *Lomaria spicant* Desv.; Munz, 44.

*CHEILANTHES CALIFORNICA* (Hook.) Mett., California Lace Fern. Abrams, 25; Jepson, 30; Munz, 35, as *Aspidotis californica* Nutt. ex Copel.

*CHEILANTHES* × *CARLOTTA-HALLIAE* Wagner and Gilbert. Not in California references (Wagner, W. H. and E. F. Gilbert, Am. Jour. Bot. 44: 738. 1957).

*CHEILANTHES CLEVELANDII* D. C. Eaton, Cleveland's Lip Fern. Abrams, 29; Jepson, 32; Munz, 34.

*CHEILANTHES COOPERAE* D. C. Eaton, Cooper's Lip Fern. Abrams, 26; Jepson, 31; Munz, 33.

*CHEILANTHES COVILLEI* Maxon, Coville's Lip Fern. Abrams, 28; Jepson, 32; Munz, 34.

*CHEILANTHES FEEI* Moore, Slender Lip Fern. Abrams, 27; Jepson, 31; Munz, 33.

\**CHEILANTHES FIBRILLOSA* Davenp., Fibrillose Lip Fern. Abrams, 27; Jepson, 31; Munz, 33.

*CHEILANTHES GRACILLIMA* D. C. Easton, Lace Fern. Abrams, 28; Jepson, 31; Munz, 33.

*CHEILANTHES INTERTEXTA* Maxon, Coastal Lip Fern. Abrams, 28; Jepson, 32, as *C. covillei* var. *intertexta* Maxon; Munz, 34.

\**CHEILANTHES PARISHII* Davenp., Parish's Lip Fern. Abrams, 27; Jepson, 31; Munz, 33.

*CHEILANTHES SILIQUOSA* Maxon, Claw Fern; Indian's Dream. Abrams, 26; Jepson, 33-34, as *Pellaea densa* Hook.; Munz, 27, as *Onychium densum* Brack.

*CHEILANTHES VISCIDA* Davenp., Viscid Lip Fern. Abrams, 26; Jepson, 31; Munz, 33.

*CHEILANTHES WOOTONII* Maxon, Wooton's Lip Fern. Abrams, not listed; Jepson, not listed; Munz, 34.

\**CRYPTOGRAMMA ACROSTICHOIDES* R. Br., American Parsley Fern. Abrams, 22; Jepson, 34; Munz, 37. Possibly a variety of *C. crispa* (L.) R. Br. according to W. H. Wagner (pers. comm., 1966).

CYRTOMIUM FALCATUM (L.f.) Presl, Holly Fern. Not in California references. An escape from cultivation at La Jolla, San Diego Co.: *Kiefer 1479* (LA); and Big Dalton Canyon, Los Angeles Co.: *Kiefer 2111* (LA).

CYOPTERIS FRAGILIS (L.) Bernh., Fragile Fern; Brittle Fern. Abrams, 7; Jepson, 38; Munz, 43.

DRYOPTERIS ARGUTA (Kaulf.) Watt, Coastal Wood Fern. Abrams, 16; Jepson, 37, as *Aspidium rigidum* Swartz var. *argutum* D. C. Eaton; Munz, 42.

\*DRYOPTERIS DILATATA (Hoffm.) A. Gray, Spreading Wood Fern. Abrams, 17; Jepson, 38, as *Aspidium spinulosum* (Muell.) Swartz var. *dilatatum* Hoffm.; Munz, 41.

DRYOPTERIS FILIX-MAS (L.) Schott, Male Fern. Abrams, 16; Jepson, 37; as *Aspidium filix-mas* (L.) Swartz; Munz, 42.

GYMNOGRAMME: see *Pitryogramma*.

LASTREA: see *Thelypteris*.

LOMARIA: see *Blechnum*.

NOTHOLAENA CALIFORNICA D. C. Eaton, California Cloak Fern. Abrams, 33; Jepson, 28, as *N. californica* but also as *N. candida* Hook. var. *accessita* Jepson; Munz, 34, misinterpreted as *Aleuritopteris cretacea* (Liebm.) Fourn., a synonym of *N. sulphurea* (Cav.) J. Smith, a species not native to California. *Notholaena californica* ssp. *nigrescans* Ewan (listed by Munz as *Aleuritopteris cretacea* ssp. *nigrescens*) is not considered distinct from the typical variety (Tryon, R., Contr. Gray Herb. 179:73. 1956).

NOTHOLAENA JONESII Maxon, Jones' Cloak Fern. Abrams, 33; Jepson, 28; Munz, 32, as *Cheilanthes jonesii* (Maxon) Munz.

NOTHOLAENA NEWBERRYI D. C. Eaton, Cotton Fern. Abrams, 32; Jepson, 27; Munz, 33, as *Cheilanthes newberryi* (D. C. Eaton) Domin.

NOTHOLAENA PARRYI D. C. Eaton, Parry's Cloak Fern. Abrams, 32; Jepson, 27; Munz, 33, as *Cheilanthes parryi* (D. C. Eaton) Domin.

\*NOTHOLAENA SINUATA (Lagasca ex Swartz) Kaulf. var. *CHOCHISENSIS* (Goodd.) Weath. Abrams, not listed; Jepson, 27, as the species; Munz, 33, as *Cheilanthes sinuata* (Lagasca ex Swartz) Domin. var. *cochisensis* (Goodd.) Munz.

ONYCHIUM: see *Cheilanthes siliquosa*.

PELLAEA ANDROMEDIFOLIA (Kaulf.) Fee, Coffee Fern. Abrams, 30; Jepson, 33; Munz, 36.

\*PELLAEA ANDROMEDIFOLIA var. *PUBESCENS* D. C. Eaton. Abrams, not listed; Jepson, not listed; Munz, 36. This variety is not recognized by A. Tryon (Ann. Missouri Bot. Gard. 44:179. 1957). Pray intends to publish on this taxon giving it subspecies status (pers. comm., 1966).

PELLAEA BRACHYPTERA (Moore) Baker, Sierra Cliff Brake. Abrams, 31; Jepson, 33; Munz, 36.

PELLAEA BREWERI D. C. Eaton, Brewer's Cliff Brake. Abrams, 29; Jepson, 32; Munz, 36.

PELLAEA BRIDGESII Hook., Bridges' Cliff Brake. Abrams, 30; Jepson, 32; Munz, 36.

PELLAEA LONGIMUCRONATA Hook., Spiny Cliff Brake. Abrams, 31, misinterpreted in part as *P. compacta* (Davenp.) Maxon, a syn. of *P. mucronata* (D. C. Eaton) D. C. Eaton var. *californica* (Lemmon) Munz and Johnston; Jepson, 33, misinterpreted in part as *P. compacta* and *P. ornithopus* Hook., the latter a syn. of *P. mucronata*; Munz, 35, misinterpreted in part as *P. compacta* and *P. mucronata* var. *californica* (Pray, T. R., Phytomorphology 16: in press. 1966).

PELLAEA MUCRONATA (D. C. Eaton) D. C. Eaton, Bird's Foot Cliff Brake. Abrams, 31; Jepson, 33, as *P. ornithopus* Hook.; Munz, 36.

\*PELLAEA MUCRONATA var. CALIFORNICA (Lemmon) Munz and Johnston. Abrams, 31, as *P. compacta* (Davenp.) Maxon; Jepson, 33, as *P. compacta*; Munz, 35, as var. *californica* but also partly as *P. compacta*. The *Pellaea compacta* entries in Abrams, Jepson, and Munz apparently include *P. longimucronata* Hook. in error as well as some forms of *P. mucronata*.

PHEGopteris: see *Athyrium alpestre*.

\*PITYROGRAMMA PALLIDA (Weath.) Alt and Grant, White Fern. Abrams, 21, as *P. triangularis* var. *pallida* Weath.; Jepson, 26, not listed, such plants apparently included with *Gymnogramme triangularis* Kaulf., a syn. of *Pityrogramma triangularis* (Kaulf.) Maxon; Munz, 38, as *P. triangularis* var. *pallida* (Alt., C. and V. Grant, Brittonia 12:168. 1960).

\*PITYROGRAMMA SEMIPALLIDA Howell. Not in California references (Howell, J. T., Leaf. West. Bot. 9:223. 1962).

PITYROGRAMMA TRIANGULARIS (Kaulf.) Maxon, Goldback Fern; Triangle Fern; Stamp Fern. Abrams, 20; Jepson, 26, as *Gymnogramme triangularis* Kaulf.; Munz, 37.

\*PITYROGRAMMA TRIANGULARIS var. MAXONII Weath. Abrams, 21; Jepson, not listed, such plants apparently included with *Gymnogramme triangularis* Kaulf., a syn. of *Pityrogramma triangularis* (Kaulf.) Maxon; Munz, 38.

\*PITYROGRAMMA TRIANGULARIS var. VIRIDIS Hoover. Not in California references (Hoover, R. F., Am. Fern Jour. 56:19. 1966). Probably best placed under the category of forma.

\*PITYROGRAMMA VISCOSA (D. C. Eaton) Maxon, Silverback Fern. Abrams, 21, as *P. triangularis* var. *viscosa* (D. C. Eaton) Weath.; Jepson, 27, as *Gymnogramme triangularis* var. *viscosa* Nutt. ex D. C. Eaton; Munz, 30, as *P. triangularis* var. *viscosa*.

POLYPODIUM CALIFORNICUM Kaulf., California Polypody. Abrams, 8; Jepson, 28, as *P. vulgare* L. var. *intermedium* Fern; Munz, 45.

\*POLYPODIUM CALIFORNICUM var. KAULFUSSII D. C. Eaton. Abrams, not listed, such plants apparently included with the species; Jepson, 28, as *P. vulgare* L. var. *kaulfussii* (D. C. Eaton) Fern.; Munz, 46.

POLYPODIUM GLYCYRRHIZA D. C. Eaton, Licorice Fern. Abrams, 8; Jepson, 28, as *P. vulgare* L. var. *occidentale* Hook.; Munz, 46.



POLYPODIUM HESPERIUM Maxon, Western Polypody. Abrams, 8; Jepson, 28, misinterpreted as *P. virginianum* L., a species not native to California; Munz, 45, as syn. *P. vulgare* L. var. *columbianum* Gilbert.

POLYPODIUM SCOULERI Hook. and Grev., Coast Polypody; Leathery Polypody. Abrams, 7; Jepson, 29; Munz, 45.

POLYSTICHUM  $\times$  CALIFORNICUM (D. C. Eaton) Underw. pro. spec., California Shield Fern. Abrams, 11, as species; Jepson, 36, as *P. aculeatum* (Swartz) Roth var. *californicum* Jepson (a misinterpretation, however, as *P. aculeatum* is not native to California); Munz, 41, as species. (Wagner, W. H., Am. Fern Jour. 53:8. 1963).

POLYSTICHUM DUDLEYI Maxon, Dudley's Shield Fern. Abrams, 12; Jepson, 36, as *P. aculeatum* var. *dudleyi* Jepson (a misinterpretation, however, as *P. aculeatum* is not native to California); Munz, 41.

POLYSTICHUM KRUCKEBERGII Wagner. Not in California references (Wagner, W. H., Am. Fern Jour. 56:4. 1966).

\*POLYSTICHUM LEMMONII Underw., Lemmon's Shield Fern. Abrams, 10; Jepson, 37; Munz, 40. Regarded as synonymous with *P. mohrioides* Presl (Wagner, W. H., Am. Fern Jour. 56:7. 1966).

POLYSTICHUM LONCHITIS (L.) Roth, Holly Fern; Narrow Holly Fern; Northern Holly Fern. Abrams, 9; Jepson, 35; Munz, 40.

POLYSTICHUM MUNITUM (Kaulf.) Presl, Western Sword Fern. Abrams, 10; Jepson, 36; Munz, 40.

\*POLYSTICHUM MUNITUM ssp. CURTUM Ewan. Abrams, not listed; Jepson, not listed; Munz, 40.

\*POLYSTICHUM MUNITUM var. IMBRICANS (D. C. Eaton) Maxon. Abrams, 10; Jepson, 36; Munz, 40.

\*POLYSTICHUM MUNITUM ssp. NUDATUM (D. C. Eaton) Ewan. Abrams, not listed; Jepson, 36, as *P. munitum* var. *nudatum* (D. C. Eaton) Gilbert; Munz, 40.

POLYSTICHUM  $\times$  SCOPULINUM (D. C. Eaton) Maxon, pro. spec., Western Holly Fern; Mountain Holly Fern. Abrams, 11, as species; Jepson, 36, as species; Munz, 41, as species. (Wagner, W. H., pers. comm., 1966).

PTERIDIUM AQUILINUM (L.) Kuhn var. PUBESCENS Underw., Western Bracken. Abrams, 23; Jepson, 30, as *Pteris aquilina* var. *lanuginosa* (Bong.) Hook.; Munz, 32, as *Pteridium aquilinum* var. *languinosum* (Bong.) Fern.

PTERIS AQUILINA: see *Pteridium aquilinum*.

PTERIS CRETICA L., Cretan Brake. Not in California references. An escape from cultivation. Santa Cruz Co., Collett s.n. (DS).

PTERIS VITTATA L., Chinese Brake; Rusty Brake. Not in California references. An escape from cultivation in canyons of the San Gabriel Mountains, Los Angeles Co.: Beach 1900, 1901 (UC), Hutt 599 (UC), Kiefer 432, 1070 (UC).

STRUTHIOPTERIS: see *Blechnum*.

THELYPTERIS NEVADENSIS (Baker) Clute ex Morton, Sierra Water



Fern. Abrams, 15, as *Dryopteris oregana* C. Chr.; Jepson, 37, as *Aspidium nevadense* D. C. Eaton; Munz, 42, as *Lastrea oregana* (C. Chr.) Copel. (Morton, C. V., Am. Fern Jour. 48:139. 1958).

*THELYPTERIS PUBERULA* (Baker) Morton. Abrams, 14, as *Dryopteris feei* C. Chr.; Jepson, 37, misinterpreted as *Aspidium patens* Swartz, a syn. of *Thelypteris patens* (Swartz) Small, a species not native to California; Munz, 42, misinterpreted as *Lastrea augescens* (Link) J. Smith, a syn. of *Thelypteris augescens* (Link) Munz and Johnson, a species not native to California. (Morton, C. V., Am. Fern. Jour. 48:139 1958.)

*WOODSIA OREGANA* D. C. Eaton, Oregon Woodsia; Western Cliff Fern. Abrams, 6; Jepson, 38; Munz, 39.

*WOODSIA SCOPULINA* D. C. Eaton, Mountain Woodsia. Abrams, 6; Jepson, 38; Munz, 39.

*WOODWARDIA FIMBRIATA* J. Smith, Giant Chain Fern. Abrams, 17, as *W. chamissoi* Brack.; Jepson, 34, misinterpreted as *W. radicans* (L.) J. E. Sm., a species not native to California; Munz, 44.

#### MARSILEACEAE. Pepperwort Family

\**MARSILEA OLIGOSPORA* Goodd, Abrams, 34; Jepson, not listed; Munz, 47. Doubtfully distinct from *M. vestita* Hook. and Grev., generally considered to be merely a dry form of the latter (Flowers, S., Ferns of Utah, p. 67. 1944).

\**MARSILEA VESTITA* Hook. and Grev., Hairy Pepperwort; Water Clover. Abrams, 34; Jepson, 39; Munz, 47. Considered by some authors to be synonymous with *M. mucronata* A. Dr.; however, we have followed C. A. Weatherby (Jour. Arnold Arb. 24:325. 1943) in maintaining the distinctiveness of *M. vestita*.

*PILULARIA AMERICANA* A. Br., American Pillwort. Abrams, 34; Jepson, 39; Munz, 47.

#### SALVINIACEAE. Salvinia Family

*AZOLLA FILICULOIDES* Lam., Duckweed Fern; Mosquito Fern. Abrams, 35; Jepson, 39; Munz, 47.

\**AZOLLA MEXICANA* Presl. Abrams, not listed; Jepson, not listed; Munz, 47, mentioned under the text of *A. filiculoides* as a possible occurrence in California.

#### ISOETACEAE. Quillwort Family

*ISOETES BOLANDERI* Engelm., Bolander's Quillwort. Abrams, 37; Jepson, 43, as *I. bolanderi* and as *I. bolanderi* var. *sonnei* Henderson; Munz, 25.

*ISOETES BOLANDERI* var. *PYGMAEA* (Engelm.) Clute. Abrams, 37; Jepson, 43, as species *I. pygmaea* Engelm.; Munz, 25.

\**ISOETES ECHINOSPORA* Dur. var. *BRAUNII* (Dur.) Engelm. ex A. Gray. Abrams, 37, as *I. braunii* Dur. but not included for California; Jepson, 43; Munz, 25, as *I. muricata* var. *hesperia* Reed. This variety

is listed as *I. echinospora* ssp. *muricata* var. *braunii* by B. Boivin (Am. Fern Jour. 51:84. 1961).

ISOETES HOWELLII Engelm., Howell's Quillwort. Abrams, 37, Jepson, 44; Munz, 26.

\*ISOETES HOWELLII var. MINIMA Pfeiffer. Not in California references (Pfeiffer, N. E., Ann. Missouri Bot. Gard. 9:142. 1922).

ISOETES NUTTALLII A. Br., Nuttall's Quillwort. Abrams, 38; Jepson, 44; Munz, 26.

ISOETES OCCIDENTALIS Henderson, Western Quillwort. Abrams, 36; Jepson, 43, as *I. lacustris* var. *paupercula* Engelm.; Munz, 25.

\*ISOETES ORCUTTII A. A. Eaton, Orcutt's Quillwort. Abrams, 38; Jepson, 44; Munz, 26.

#### EQUISETACEAE. Horsetail Family

EQUISETUM ARVENSE L., Field Horsetail. Abrams, 39; Jepson, 41; Munz, 28.

\*EQUISETUM ARVENSE var. BOREALE (Bong.) A. A. Eaton. Abrams, not listed; Jepson, 41; Munz, not listed. Indications are that var. *boreale* is merely a shade form of the species and should not be recognized taxonomically (Hauke, R. L., pers. comm., 1965).

EQUISETUM  $\times$  FERRISSII Clute, pro spec. Abrams, 42, misinterpreted as *E. laevigatum* A. Br., another species; Jepson, 40, misinterpreted in part as *E. laevigatum* and as *E. hyemale* var. *intermedium* A. A. Eaton, the latter a synonym of *E.  $\times$  ferrissii*; Munz, 27, misinterpreted as *E. laevigatum*, another species. (Hauke, R. L., Am. Fern Jour. 50:193. 1960).

EQUISETUM HYEMALE L. var. AFFINE (Englm.) A. A. Eaton, Scouring Rush. Abrams, 42, as *E. prealtum* Raf. and *E. hiemale* var. *californicum* Milde; Jepson, 40, as *E. hiemale* var. *californicum* Milde, var. *herbaceum* A. A. Eaton and var. *robustum* (A. Br.) A. A. Eaton; Munz, 27 and 29, as *E. hyemale* var. *robustum* (A. Br.) A. A. Eaton and var. *californicum* Milde. (Hauke, R. L., Am. Fern Jour. 50:191. 1960).

EQUISETUM LAEVIGATUM A. Br., Smooth Scouring Rush. Abrams, 40, as *E. funstonii* A. A. Eaton and *E. kansanum* J. H. Schaffner; Jepson, 40, as *E. laevigatum* but also as *E. funstonii*, *E. funstonii* vars. *caespitosum* (A. A. Eaton) Jepson, *nudum* (A. A. Eaton) Jepson and *ramosum* (A. A. Eaton) Jepson; Munz, 27, as *E. laevigatum* but also as *E. funstonii* and *E. kansanum*. (Hauke, R. L., Am. Fern Jour. 50:192. 1960).

\*EQUISETUM PALUSTRE L., Marsh Horsetail. Abrams, not listed; Jepson, 41; Munz, not listed. Doubtful if found in California; no confirming herbarium specimens found.

EQUISETUM TELMATEIA Ehrh. var. BRAUNII (Milde) Ehrh. Giant Horsetail. Abrams, 39, misinterpreted as *E. telmateia* Ehrh., only the variety native to California; Jepson, 41; Munz, 27.

## LYCOPODIACEAE. Club-moss Family

LYCOPODIUM CLAVATUM L., Running Club-moss. Abrams, 45, but not included for California; Jepson, 41; Munz, 22.

LYCOPODIUM INUNDATUM L., Bog Club-moss. Not in California references. Dorothea Luhr (Am. Fern Jour. 48:61. 1959) reported finding this plant at Big Lagoon State Park, Humboldt Co.; however, the plant has been known from this area since 1929, *Kildale 8397* (DS).

## SELAGINELLACEAE. Selaginella Family

SELAGINELLA ASPRELLA Maxon, Bluish Selaginella. Abrams, 50; Jepson, not listed; Munz, 24.

SELAGINELLA BIGELOVII Underw., Bushy Selaginella. Abrams, 47; Jepson, 42; Munz, 23.

SELAGINELLA CINERASCENS A. A. Eaton, Pygmy Selaginella; Gray Selaginella. Abrams, 47; Jepson, 42, as *S. bryoides* Underw.; Munz, 24.

\*SELAGINELLA DOUGLASII (Hook. and Grev.) Spr., Douglas' Selaginella. Abrams, 46; Jepson, 42; Munz, 23. Of doubtful occurrence in California (Jones, G. N., Am. Fern Jour. 54:83. 1964).

SELAGINELLA ENGELMANNII Hieron. var. SCOPULORIUM (Maxon) Reed, Rocky Mountain Selaginella. Abrams, as *S. scopulorum* Maxon but not included for California; Jepson, not listed; Munz, 24, as *S. densa* var. *scopulorum* (Maxon) Tryon (Reed, Phytologia 9:499. 1964).

SELAGINELLA EREMOPHILA Maxon, Desert Selaginella. Abrams, 47; Jepson, 42, misinterpreted as *S. parishii* Underw., a species not native to California; Munz, 24.

SELAGINELLA HANSENII Hieron., Hansen's Selaginella. Abrams, 48; Jepson, 42, as *S. rupestris* (L.) Spr. var. *hensenii* Jepson and *S. rupestris* (L.) Spr. var. *bolanderi* (Hieron.) Jepson; Munz, 24.

SELAGINELLA LEUCOBRYOIDES Maxon, Mojave Selaginella. Abrams, 49; Jepson, not listed; Munz, 24.

SELAGINELLA OREGANA D. C. Eaton, Oregon Selaginella. Abrams, 48; Jepson, 42, as *S. struthioloides* Underw.; Munz, 24.

SELAGINELLA WALLACEI Hieron., Wallace's Selaginella. Abrams, 49; Jepson, 42, misinterpreted as *S. rupestris* var. *fendleri* Underw. which is a synonym of *S. underwoodii* Hieron., a plant not native to California; Munz, 24.

SELAGINELLA WATSONII Underw., Alpine Selaginella. Abrams, 49; Jepson, 43; Munz, 24.

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## A NEW HESPERALOE FROM SONORA, MEXICO

HOWARD SCOTT GENTRY

**Hesperaloe nocturna** Gentry, sp. nov. Planta perennis, acaulis, multi-caespitosa, 1–1.4 m alta, ad 1–2 m late; foliis 100–150 cm longis, 1–2 cm latis ad basim, linearis longiapiculatis supra plana et crassa ad basim, canaliculata ad apice, viridibus striatis, margine angusto brunneo sparse-filifero, apice pungens vel asperigilliformis aetate pro-  
vocal inflorescentia racemosa, gracila, 1.2–2 m longa, simplice vel 1–3-ramosus; flores pedicellates, fasciculates, noctiflorus, 25–30 mm longes; tepala pruinosa-violacea, adpressa vel reflexa anthesis nocturna, 15–18 mm longa, 5 mm lata; filamenta glabra 8–9 mm longa ad basim tepala inserta; antheris sagittatis 8–9 mm longis in corolla inclusis; ovario 8–9 mm longo, oblongo; styli 8 mm longi crassi; stigmata capitati papilloso; capsulae 3–4 cm longae, 3.5–4.5 cm latae, depresso-ovoidae vel oblongae, rugosae apiculatae; semina grandii nigra,  $8 \times 11$  mm.

Acaulescent, densely caespitose rosettes forming large clumps about 1.5 m tall and 1–2 m broad; leaves narrowly linear, 1–1.5 m long, 1–2 cm broad near the base, striate, plane towards the base and deeply concave upwards on the upper side, deeply rounded below, tip acicular and pungent, fraying in age; margin narrow, brown, irregularly and finely filiferous; inflorescence slender, 1.5–2 m tall, a simple or 2–3-branched arching raceme on long peduncles; bracts of the peduncle dry, lanceolate, 6–4 cm or less long; bracteoles chartaceous, 3–5 mm long, obtuse to acute; flowers 24–30 mm long, fasciculate on unequal pedicels 5–18 mm long, 4 to 6 or 8 at the node, nocturnal, pruinose pink to lavender in the bud, greenish below, stipitate on a pedicellar joint; tube 2–3 mm long; tepals 15–22 mm long, reflexing at nocturnal anthesis, other-times appressed, whitish within, the outer tepals pink or lavender on the back and narrower than the inner, the inner with a broad flat keel and greenish pink or greenish lavender on the back; filaments equaling the pistil, 8–9 mm long, attached to base of tepals; anthers sagitate, versatile, 8–9 mm long; ovary 8–9 mm long above tube base, green, trigonous, oblong, roundly angled at the apex, ringed at the base with nectary; style 8 mm long, stout, stigma capitate, papillate; capsules depressed ovoid or oblong, 3–4 cm long, 2.5–4.5 cm broad, apiculate, rugose; seeds large, black,  $8 \times 11$  mm.

Holotype: *Gentry & Felger 19988* (US), 15 miles southeast of Magdalena along road to Curcurpe, by Sierra Baviso, Sonora, Mexico, alt. 3200–3500 feet, May 21, 1963.

Also at the type locality: *Gentry 19890* (US), April 1 (sterile); *Felger 3458* (US), July 16, 1960; *Wiggins 7132* (US), talus slope of basaltic cliff toward south end of Baviso Mts., 17 miles southeast of Magdalena, Sept. 11, 1934. The description of the flowers is drawn from preserved material collected at the time of anthesis. The dried specimens are much smaller.





FIG. 1. *Hesperaloe nocturna* with flower, N, compared with flower and inflorescence section of *H. parviflora*, P.

The two other species known in this genus occur east of the continental divide, *H. parviflora* (Torr.) Coult. in Texas and *H. funifera* (Koch) Trel. in northeastern Mexico. Trelease (1902) gave an historical account of them. He observed *H. parviflora* in cultivation and



FIG. 2. *Hesperaloe nocturna* southeast of Magdalena. The clumps are like "bear grass."

noted considerable variation in the size and color of flowers on the same plant during the several months of flowering. In both *H. parviflora* and *H. nocturna* the flowers appear one by one at any given node, so there is little apparent progression up or down the raceme. First examination of the Sonoran collections tentatively assigned them to var. *engelmannii* under *H. parviflora*, but with subsequent consideration of the morphology and biology I evaluate the differences at the specific level. The strictly nocturnal flowering of *H. nocturna* is of particular importance in separating it from the other two species with diurnal flowers. Speculatively, the reflexing of the tepals with their whitish interior are correlative to pollination by night-flying insects, while the red, tubular form of the diurnal flower is indicative of bird pollinators. Other structures, such as the large nocturnal anthers and the small diurnal anthers, may also reflect biotic adaptations. The following synoptical key shows the more contrasting characters of the two relatives.

- Leaves large and coarse, 3–6 cm wide near the base and to 2 m long,  
nearly straight, with coarse white marginal filiferae;  
flowers greenish tinged with purple . . . . . *funifera*
- Leaves smaller, 1–3 cm wide near the base and 1–1.5 m long,  
arcuately spreading, with very fine marginal filiferae
  - Flowers nocturnal, greenish lavender, with a short tube; tepals  
reflexed at anthesis; filaments short (8–9 mm) with  
large anthers (8–9 mm); ovary large (8–9 mm long), oblong,  
imbedded in receptacle; style short (8 mm), stout . . . . . *nocturna*
  - Flowers diurnal, dark red to light red, tubeless; tepals appressed  
at anthesis; filaments elongate (13–14 mm) with small anthers  
(4 mm); ovary small (4–5 mm long), ovoid, free of receptacle;  
style elongate (12–13 mm), slender . . . . . *parviflora*



FIG. 3. *Hesperaloe nocturna* southeast of Magdalena. The capsules show the generic difference between it and "bear grass."

Figure 1 compares the floral structures of *H. nocturna* and *H. parviflora*, drawn respectively from the type and Gentry 19966 from Richardson, Texas. The development of a short but definite tube is unusual in the Yuccaceae, but has been observed in other members, as *Yucca carnerosana* (Trel.) McKelvey. Of special significance is the ovarian tissue imbedded in the fleshy receptacle of *H. nocturna*, or a tendency of the tube to grow up around the ovary, leading towards an inferior position of the ovary exhibited in other members of the Agavaceae, where it is not always completely inferior. *Manfreda guttata* (Jacobi & Bouché) Rose (*A. protuberans* Engelm.) and *Agave striata* Zucc. both have ovaries that protrude into the tube and hence are incompletely inferior.



Further observations may discover still other agavoid taxa to bridge the gap between the superior ovary of the Liliaceae and the inferior ovary of the Amarillidaceae, the principal character conservatively aligning the Agaves with the Amaryllids.

*Hesperaloe nocturna* is patently rare, as it is not known from other collections or places. However, as much of northeastern Sonora has not been botanized, it may be expected in other Sonoran localities. This occurrence records the genus from west of the continental divide. In appearance the plants closely resemble the clumped "bear grass," *Nolina microcarpa* S. Wats., which occurs in the same region (figs. 2, 3). Doyle Noel of the USDA Plant Quarantine Station in Nogales, Arizona, first called the plant to my attention. Plants are presently growing in his garden and he can be credited with making the first introduction.

Transplants are also responding well in the Desert Botanical Garden, Phoenix, Arizona. No native names or uses were obtained for the plant.

U.S. Department of Agriculture, Agricultural Research Service,  
Crops Research Division, Beltsville, Maryland

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TRELEASE, W. 1902. The Yuccae. Missouri Bot. Gard. Rep. 13:27-31, pls. 1-4.

#### NOTES AND NEWS

LASTHENIA GLABRATA REMAINS DIPLOID.—Recently Mehra et al. (Caryologia 18:35-68. 1965) reported  $n = 14$  for the helenioid composite *Lasthenia glabrata* Lindl. This count was based on plants of unspecified origin cultivated in Chandigarh, India. In view of my determination of  $n = 7$  for plants in several populations of this species in its native California (Univ. Calif. Publ. Bot. 40:1-92. 1966), this record of an apparent tetraploid is of unusual interest. In response to my request, achenes of the Indian plants were sent through the courtesy of Prof. Mehra, and were subsequently planted in Berkeley. Upon flowering, it was clear that the plants belonged to *L. chrysostoma* (F. & M.) Greene, a species known to have  $n = 8$  and  $n = 16$  but not  $n = 14$ . Although hypotetraploids in this species would be of unusual cytophyletic interest, examination of microsporogenesis in them indicated that they have  $n = 16$  rather than  $n = 14$ . Meiosis was characterised by sticky chromosomes in the first meiotic division and this may have led Mehra and his co-workers to an impression of fewer chromosome pairs than exist. In fact, it is possible to reinterpret fig. 33 published by them as  $n = 16$ , if it is assumed that one of the alleged bivalents is a pair of loosely associated bivalents, and that what appear to be two sets of dissociated bivalents are each trivalents, or that perhaps the large ringlike figure is a quadrivalent. I am indebted to T. F. Niehaus for his assistance with this problem.—ROBERT ORNDUFF, Dept. of Botany, University of California, Berkeley.



# STUDIES OF JUNIPER RUSTS IN THE WEST

ROGER S. PETERSON

Included here are a review of *Gymnosporangium* species that occur in the Great Basin and a description of a new species of rust fungus on *Juniperus deppeana* in the Southwest. No taxonomic changes are proposed for the 11 species known in the Great Basin (which includes most of Nevada, half of Utah, and parts of California and other adjacent States), but amendments to published descriptions are pointed out, new data on ecology, hosts, and distribution are given, and the life cycle of *G. kernianum* is established on the basis of inoculations. One species that does not infect juniper, *G. libocedri*, is included to complete the roster of *Gymnosporangium* for the Great Basin.

Hyphenated numbers are those of the author's collections, the first digits representing the year. Specimens are housed in the Forest Service herbarium at Logan, Utah, and in the National Fungus Collections at Beltsville, Maryland.

## GYMNOSPORANGIUM IN THE GREAT BASIN

Previous keys to telial stages have included as primary criteria some—but not all—of the symptoms caused by these fungi, and only some of the host organs on which telia are found. As a result, many specimens could not be reached in the keys. The following artificial key emphasizes fungus morphology, with some attention to host range where this is constant. Descriptions of shapes apply to telia before they gelatinize.

Many teliospores with 1 or 3 cells.

Telia round; brown or red-brown.

Apical germ pore usually present; on *Heyderia* . . . . . *G. libocedri*

Apical germ pores lacking; on *Juniperus* . . . . . *G. kernianum*

Telia elongate; orange . . . . . *G. speciosum*

Teliospores with other than 2 cells rare or lacking.

Many teliospore germ pores apical or scattered.

Germ pores several per cell, scattered . . . . . *G. multiporum*

Germ pores 1 or 2 per cell, near crosswall or apical.

Telia more than 2 mm diameter; on *J.* sect. *Juniperus* . . . *G. tremelloides*

Telia less than 2 mm diameter; on *J.* sect. *Sabina*.

Most pedicel-tops swelling greatly in water . . . . . *G. inconspicuum*

Pedicels remaining cylindric in water . . . . . *G. nidus-avis*

Nearly all teliospore germ pores near crosswalls.

Telia mostly broader than high: hemispherical or indefinite mounds.

Teliospores  $12-26 \times 39-61\mu$ ; a few pores apical . . . . . *G. nidus-avis*

Teliospores  $20-30 \times 41-80\mu$ ; no apical pores . . . . . *G. kernianum*

Telia higher than broad; cylindric, conic, frustum- or tongue-shaped.

Telia cylindric or club-shaped, tan to yellow-orange . . . *G. clavariiforme*

Telia tapering upward; chestnut- to chocolate-brown.

Telia less than 2 mm high; not on galls.

Spore tips often protuberant; pores not papillate . . . *G. harknessianum*

Spore tips seldom protuberant; pores usually papillate . . *G. kernianum*

Telia often more than 2 mm high; usually on galls.

Average length brown-wall spores less than  $50\mu$  . . . . . *G. bethelii*

Average length brown-wall spores more than  $50\mu$  . . . . *G. nelsonii*



FIGS. 1-4. 1, Aecia of *Gymnosporangium harknessianum* on *Amelanchier*; 2, aecia of *G. kernianum* (left) and *G. inconspicuum* (right) in the same collection on *Amelanchier utahensis*; 3, teliospores of *G. harknessianum* from *Juniperus occidentalis*,  $\times 515$ ; 4, teliospores of *G. kernianum* from *Juniperus osteosperma*,  $\times 515$ .

Discussion that expands upon treatments by Arthur (1934) or Kern (1911, 1964), rather than repetitive description, follows for the above species, alphabetically arranged. New western records from outside the Great Basin are listed in separate paragraphs.

*GYMNOSPORANGIUM BETHELII* Kern. Rhoads' discussion (1946) supplements previous inadequate descriptions of symptoms. *Gymnosporangium bethelii* is abundant on *Juniperus scopulorum* and *Crataegus rivularis* in the parts of Utah, Idaho, and Wyoming that are in the Great Basin. *C. rivularis* in the Basin is almost restricted to riverbanks and moist canyons, and the rust is similarly restricted. *Gymnosporangium*

*bethelii* has not been collected in Nevada, where *Crataegus* may be restricted to part of Elko Co. (McVaugh, 1942), and occurs mostly at lower elevations than *J. scopulorum*.

*Gymnosporangium bethelii* has not previously been reported from Arizona but is common there on *J. scopulorum* in Oak Creek Canyon, Coconino Co. (66-37).

The key characteristic given above to separate *G. bethelii* from *G. nelsonii* may not prove satisfactory when more collections are examined, but on account of their distinct aecial states the two fungi should be maintained as separate. The matter is discussed further under *G. nelsonii*, below. I did not study whether *G. bethelii* is distinct at the species level from eastern *G. globosum* Farl., which is somewhat similar in all spore stages.

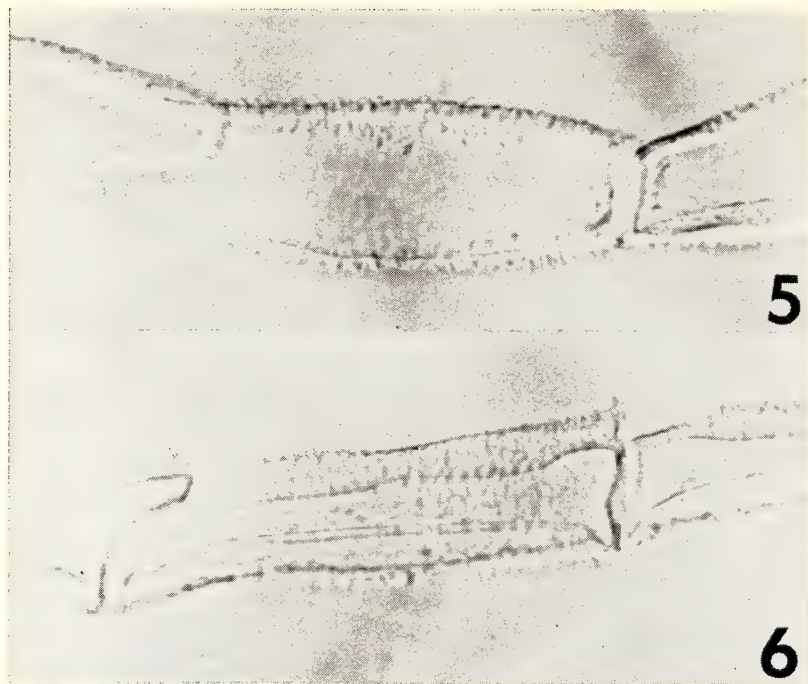
GYMNOSPORANGIUM CLAVARIIFORME (Pers.) DC. Krebill (1967) showed variations in morphology and effects of this species, which can cause witches'-brooms as well as woody swellings on juniper. *Gymnosporangium clavariiforme* is not abundant in the Great Basin, but Krebill found that it is occasional on *Juniperus communis* in Utah, and he has collected it on that host just outside the Great Basin in western Wyoming and southeastern Idaho. It also appears to be only occasional—or at least rarely collected—on *Amelanchier alnifolia* and *A. utahensis* in Utah. It is not yet recorded from the western half of the Basin.

*Gymnosporangium clavariiforme* occurs in Oregon on *Crataegus columbiana* (63-232 from North Burnt River, Baker Co.) and has previously been recorded in the other Pacific Coast States.

Aeciospores of this species are often larger than recorded in American descriptions. Sixty spores from a collection obtained from artificial infection on *A. alnifolia* (R. G. Krebill 388) measured  $23-30 \times 28-37\mu$  with an average of  $27 \times 32\mu$ . A collection on *A. utahensis* from northern Utah (Kreibill 186) averaged  $26 \times 33\mu$ , with a few spores as large as  $33 \times 42\mu$ . Specimens in which the aecia remain firm and finally dehisce apically are common but cannot be reached in present keys.

GYMNOSPORANGIUM HARKNESSIANUM Kern ex Arth. This species has not previously been recorded from the Great Basin. It occurs there not only in the eastern Sierra Nevada on the known telial host, *Juniperus occidentalis* (63-174 from Fallen Leaf Lake, Eldorado Co., California, and W. W. Wagener F. P. 97510 from Cascade Creek in Alpine Co., California) but also in the hills of western Nevada on new hosts: *J. osteosperma* and *Amelanchier utahensis* (65-131 and 65-132 from Flowery Ridge, Storey Co.). The latter collections were within two meters of one another. The occurrence of this fungus in relatively dry pinyon-juniper woodland establishes a newly recorded ecologic habitat as well as a new State and host record. In *A. utahensis* the fungus is perennial and causes cankers up to 30 cm long. Aecia range up to 15 mm high (fig. 1), exceeding those of any other species in the Great Basin and exceeding previous measurements for *G. harknessianum*.





FIGS. 5-6. Peridial cell of *Gymnosporangium kernianum*: 5, in face view,  $\times 600$ ; 6, in side view,  $\times 600$ . The concave, smooth outside wall appears to be within the cell.

Aeciospores in a 100-spore sample averaged  $25 \times 30\mu$ , and their range of dimensions,  $20-29 \times 24-37\mu$ , is much greater than previously recorded. However, similar dimensions are present in my collections on *A. pallida* from California and Oregon, so the large size is not an effect of *A. utahensis*. A parallel situation exists for teliospores: on *J. osteosperma* the largest seen were  $23 \times 96\mu$ , to be compared with the  $22 \times 72\mu$  maxima given for *G. harknessianum* by Arthur (1934). However, three collections on *J. occidentalis* all contained teliospores as long as  $87\mu$ , with a maximum of  $98\mu$  in *F. P.* 97510 (cited above). The tendency of this species to have part of the teliospore wall concave (fig. 3) distinguishes it from some related species, for instance *G. kernianum* (fig. 4).

**GYMNOSPORANGIUM INCONSPICUUM** Kern. This is by far the most abundant *Gymnosporangium* on juniper and one of the most abundant species on *Amelanchier* in the Great Basin. McVaugh (1942) wrote that "... in some areas ... of the Great Basin the *Amelanchier* fruits may be so heavily infested that it is almost impossible to find one maturing normally; the infected fruits are often colored bright yellow or orange by the rust, so that whole bushes may appear at first glance to bear yellow or orange fruit." It is almost entirely *G. inconspicuum*



that causes these color effects; other species are much less common on fruits in the Basin and are much less bright in color.

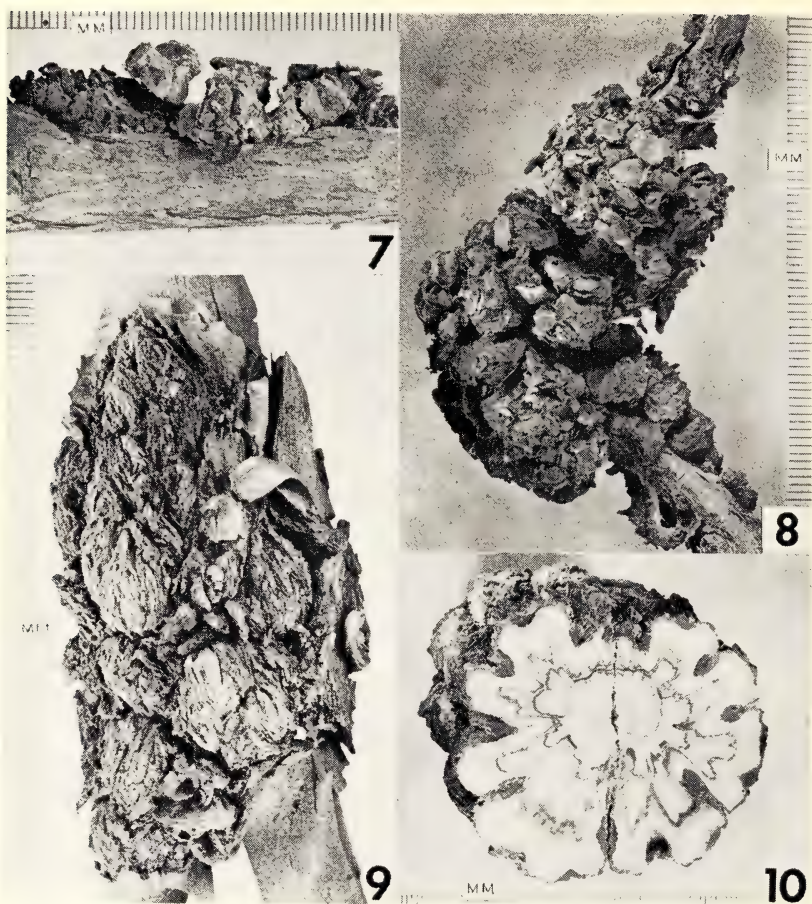
Telia can be found in almost any stand of *J. osteosperma* throughout the millions of acres of this species in Utah and Nevada. *G. inconspicuum* is as common on older branches and larger stems as on the green twigs from which it has been reported before. Swelling of host tissue is slight or lacking in most stem infections, but the bark becomes abnormally rough. Although telia usually fall off green twigs after gelatinization, leaving no obvious sign of infection, on woody bark they are often retained in the cracks so that the disease can be diagnosed at any time of year. Sometimes telia are associated with ill-defined witches'-brooms on *J. osteosperma*, but no systemic mycelium was found and a causal relation was not established. The fungus does cause woody swellings, but only rarely.

*Gymnosporangium inconspicuum* is newly recorded from Nevada (many collections, including 63-333 on *A. utahensis* and 63-334 on *J. osteosperma* from the Grant Range, Nye Co.); Idaho (66-11 on *J. osteosperma* from the Bear River Range, Franklin Co.); and Wyoming (66-7 on *J. osteosperma* from the Crawford Mountains, Lincoln Co.).

Outside the Great Basin, newly recorded hosts of *G. inconspicuum* are *J. deppeana* (65-55 from the Chiricahua Mountains, Cochise Co., Arizona, and 66-36 from Oak Creek Canyon, Coconino Co., Arizona) and *J. monosperma* (65-58 from Bear Mountain, Grant Co., New Mexico, and 66-41 from Showlow, Navajo Co., Arizona). On *J. monosperma* the fungus appears to cause release of a few dormant buds but no well-developed witches'-brooms. On *J. deppeana* the telia collected were on woody twigs and, in one instance, on a large gall caused by *G. speciosum*. *Gymnosporangium inconspicuum* is also common on *J. osteosperma* in the Southwest (61-44 and 66-31 from the Kaibab Plateau, Coconino Co., Arizona) and is often the only *Gymnosporangium* to be seen on this host under arid conditions, for instance in Petrified Forest National Park.

Although later manuals list only *J. osteosperma* as telial host of *G. inconspicuum* and have Arizona and Utah as its western limits, Blasdale (1919) recorded the species on *J. occidentalis* from Big Bear Valley in San Bernardino Co., California. Two of E. Bethel's collections on which Blasdale's record was based appear to me to have been correctly identified as *G. inconspicuum*.

*GYMNOSPORANGIUM KERNIANUM* Bethel. This fungus is locally common on *J. osteosperma* and occurs on *Amelanchier utahensis* virtually throughout the Great Basin. Unlike *G. inconspicuum* and *G. nelsonii*, however, it is absent from many stands where these alternate hosts occur together. It was found in Wyoming (66-5 on *J. osteosperma* from the Crawford Mountains, Lincoln Co.) in addition to States previously recorded.



FIGS. 7-10. 7-8, Galls caused by *Gymnosporangium nelsoni* on *Juniperus* sp. near Zitácuaro, Michoacán; 9, galls caused by *G. speciosum* on *Juniperus deppeana* in the Chiricahua Mountains, Arizona; 10, cross-section of a *G. speciosum* gall like that in fig. 9.

Arthur's description (1934) of the aecia on *Amelanchier* was based on a wrong concept of the species, so Kern (1964) omitted *Amelanchier* as a host and substituted a corrected concept based on specimens on *Pyrus*, *Cydonia*, and *Crataegus*. However, in many of the Great Basin mountain ranges where *G. kernianum* is common, *Amelanchier* is the only one of these rosaceous genera present. Scores of collections of rust fungi on *A. utahensis* were examined; one (65-466 from the Pequop Mountains, Elko Co., Nevada) was found to include *G. kernianum*. The aecia on *Amelanchier* fruits are inconspicuous among the larger, brighter, and more abundant aecia of *G. inconspicuum* (fig. 2).

Previous inoculations to establish the life cycle of *G. kernianum* resulted in the production of spermogonia but not aecia on *Amelanchier* (Arthur, 1934). Production of aecia would have averted the 30-year misunderstanding of the species. Because Kern's new description of the aecia, too, was not confirmed by inoculation results, on 12 May 1966, I inoculated two shoots of a potted *Amelanchier alnifolia* in the greenhouse by suspending over them telia on *J. osteosperma* (66-4 from Rich Co., Utah). Abundant spermogonia appeared on leaves (both surfaces) on 19 May and continued to be produced for several weeks on the inoculated shoots. Other equally succulent shoots on the same plant remained free of infection, as did inoculated seedlings of *Malus sylvestris* cv. Red Delicious and cv. Winesap. Aecial initials were first observed on *Amelanchier* on 6 June but no aecia were mature until 20 June. Between then and 12 July when the leaves were harvested (66-16), about 50 aecia were produced from about 10 infections, and most of them began to dehisce; scores of other infections did not go beyond the spermogonial stage in spite of attempts to crossfertilize them. Aecia were mostly on lower leaf surfaces.

Aecia of this "pedigreed" specimen are roestelioid and 1-3 mm high. Peridial cells vary from linear rhomboidal to (mostly) boat shaped: the outer surface is concave, forming the interior of the "boat," and the sides curve inward to the rounded "bottom" (figs. 5, 6). Peridial cells from halfway up an aecium are  $24-33 \times 61-110\mu$  in face view and  $24-41\mu$  thick. Inner and side walls are moderately verrucose for the most part, but there are usually some cylindrical tubercles 3 or  $4\mu$  high, especially near the "gunwales." Sidewalls are about  $4\mu$  thick and inner walls are  $4-13\mu$  thick. Outer walls are smooth and usually about  $1.5\mu$  thick, or occasionally as much as  $3\mu$ . Aeciospores in a 50-spore sample measured  $22-28 \times 23-33\mu$  with an average of  $25 \times 28\mu$ . Aeciospore walls are yellow-brown,  $1.5-2.5\mu$  thick and finely verrucose; they bear six to nine conspicuous germ pores.

Although the cultured aecia did not seem to contain any very long peridial cells, I have no doubt that they represent the same taxon in which cells more than  $200\mu$  long were found (Peterson, 1963). Although mature, the greenhouse-grown aecia as well as peridial cells are smaller than in natural collections. Perhaps *Amelanchier* leaves are an unfavorable substrate for the fungus in comparison with fruits of this or other genera.

Telia of *G. kernianum* have been described as caulicolous (Arthur, 1934). Microtome sections of telia in four specimens showed them to be of subhypodermal origin on leaves rather than on stems. Mycelium occurs throughout both leaves and stems.

*Gymnosporangium kernianum* is much more widely distributed than Arthur (1934) recorded. Cummins (1964) found it in Texas. It is also on *J. californica* in California (65-35 near Jacumba, San Diego Co., and *R. G. Krebill* 249 from Phelan, San Bernardino Co.) and in Baja



California (65–27 from the western foothills of the Sierra San Pedro Mártir)—a first record from Mexico. In Arizona it infects *J. osteosperma* (62–137 from the South Rim, Grand Canyon National Park) as well as *J. deppeana*.

On *J. californica*, a newly recorded host species, some teliospore walls are much thicker than previously recorded for *G. kernianum*, as much as  $3\mu$  or rarely  $5\mu$  thick including the occasional apical ornamentation. Most spores, however, have smooth walls  $0.8$ – $1.5\mu$  thick as on other Junipers.

GYMNOSPORANGIUM LIBOCEDRI (P. Henn.) Kern. This species with telia on *Heyderia decurrens* and aecia on *Amelanchier* and other genera is the only *Gymnosporangium* in the Great Basin that does not inhabit juniper. It is abundant on *Heyderia* in the Sierra Nevada, including the western Nevada portion of this mountain range. The common, conspicuous witches'-brooms caused by this fungus represent only a minute percentage of infections, most of which do not become systemic.

This species is surely the most abundant *Gymnosporangium* in northern California, at least in recent years. It is surprising that it is quite uncommon south of Yosemite National Park, and I could find none of it on *Heyderia* in Baja California.

GYMNOSPORANGIUM MULTIPORUM Kern. This seldom-collected species is the only *Gymnosporangium* of unknown life cycle in the Great Basin. It occurs on *Juniperus occidentalis* in Eldorado Co., California, but has not yet been found in typical Great Basin habitats.

Kern and Keener (1960) hypothesized that *Peridermium ephedrae* is the aecial state of *G. multiporum*. My inoculations with *P. ephedrae* aeciospores, which were kindly supplied by Professor Keener, failed to produce infection on *J. osteosperma*, *J. virginiana*, or *Ephedra viridis*. I do not believe that any *Ephedra* grows near Fallen Leaf Lake, where *G. multiporum* was collected in Eldorado Co.

GYMNOSPORANGIUM NELSONII Arth. This species is occasional to abundant throughout the Great Basin, and is the only *Gymnosporangium* known on both principal junipers of the area, *J. osteosperma* and *J. scopulorum*. It is also abundant in some years on *Amelanchier alnifolia*, *A. utahensis*, and, very locally, on *Peraphyllum ramosissimum* in the Basin.

*Gymnosporangium nelsonii* infects *J. californica* in the vicinity of Jacumba, San Diego Co., California—both a new host and a new State for the fungus (65–34).

*Gymnosporangium nelsonii* and *G. bethelii* are very similar in the telial state. In my collections the overall size ranges for teliospores are  $17$ – $28 \times 41$ – $74\mu$  in *G. nelsonii*  $15$ – $26 \times 32$ – $65\mu$  in *G. bethelii*. However, many *G. nelsonii* collections lack distinctively long spores. Inter-sextile lengths (the sixth largest and sixth smallest omitted) of spores with colored walls are more helpful:  $50$ – $59\mu$  in *G. nelsonii* and  $46$ – $53\mu$  in *G. bethelii*. Spores with walls that are hyaline or nearly so are present in most collections; in *G. bethelii* they average longer than spores



with definitely brown walls. Teliospores of *G. nelsonii* tend to have narrower ends than the rounded spores of *G. bethelii*. Usually the two can be distinguished because *G. nelsonii* in the Great Basin produces a single, subglobose gall from each infection whereas *G. bethelii* produces a canker and a series of irregular galls. But these symptoms intergrade and in any event are useless for identification of young infections.

Specimens tentatively identified as *G. nelsonii* were collected from *Juniperus flaccida* in the State of San Luis Potosí, Mexico (63-46, from Barranca de los Mármoles) and on *Juniperus* sp., sect. *Sabina*, in the state of Michoacán (63-46, from near Zitácuaro). These specimens, and also those from Michoacán and Texas mentioned by Cummins (1964) and one on *J. deppeana* from Hidalgo illustrated by Martínez (1963), display symptoms unlike any described for *G. nelsonii*. The cankers with their series of lobed, stalked galls from a single infection (figs. 7, 8) resemble those of *G. bethelii* more than typical infections of *G. nelsonii*. The teliospores, however, are longer even than typical *G. nelsonii* and quite unlike *G. bethelii*.

Another doubtful assignment to *G. nelsonii* is collection 64-187 on leaves of *Amelanchier utahensis* from a near-desert woodland east of Escalante, Utah. Aeciospore walls are unusually dark chocolate brown, perhaps an example of desert melanism. Aeciospore dimensions in a 50-spore sample are  $23-33 \times 27-37\mu$  with an average of  $27 \times 32\mu$ —larger than previously described for *G. nelsonii* or indeed, for any rust fungus on *Amelanchier* leaves except *G. clavariiforme* as it is described above. Peridial cells were like those of *G. nelsonii*, and galls of this species as well as *G. inconspicuum* infections were nearby on *J. osteosperma*.

**GYMNOSPORANGIUM NIDUS-AVIS** Thaxter. This species is locally common to abundant on *J. scopulorum* and *Amelanchier* spp. in the three eastern States of the Great Basin—Wyoming, Idaho, and Utah. I have not yet seen specimens from Nevada.

*Gymnosporangium nidus-avis* causes witches'-brooms on *J. scopulorum* similar to those of *G. kernianum* on *J. osteosperma*; also, the spore descriptions of the two species overlap to a confusing extent. Nevertheless, they are distinct fungi. Probably in all telial collections of *G. nidus-avis* a substantial number of spores have apical germ pores, which is not true of *G. kernianum*. Also they are host specific—even where *J. scopulorum* and *J. osteosperma* are closely mingled it is common to see one of them heavily infected by its own peculiar broom-rust parasite, whereas the other juniper is free of rust.

**GYMNOSPORANGIUM SPECIOSUM** Peck. This species is locally common on *J. osteosperma* and *Philadelphus* in southern and eastern Utah. Its symptoms on *J. osteosperma* include witches'-brooms as well as fusiform galls (Rhoads, 1946). Sometimes whole trees appear to be infected, with telia in small patches scattered over the rough-barked trunks and branches.

Swellings caused by *G. speciosum* are described as "gradually fusiform" (Kern, 1964). The distinctive galls that it causes on *J. deppeana* (figs. 9, 10) are often rather abrupt, and large ones are 35 cm or more in diameter, some of them almost spherical. Others are elongate and may resemble those on *J. mexicana*, illustrated by Cummins (1943).

Although most witches'-brooms on *J. deppeana* are caused by *G. kernianum*, in the Santa Rita Mountains of southern Arizona I observed on this host occasional brooms associated with long-fusiform swellings caused by *G. speciosum*.

#### A NEW SPECIES OF RUST FUNGUS ON JUNIPERUS

**Uredo apacheca** R. Peterson, sp. nov. Urediniis forma irregulari, exiguis vel usque ad  $3 \times 10$  mm, plerumque occultatis sub cortice, albidis vel pallide flavidis; peridio crassitudine cellula unica, fragile; cellulis peridii oblongis, plerumque  $24-35 \times 35-45\mu$ , ca.  $15-20\mu$  cr., membrana verrucosa; urediniosporis in catenis, ellipsoideis vel piriformibus,  $16-33 \times 25-54\mu$ , plerumque  $21-26 \times 27-33 \mu$ , membrana inaequaliter  $(1.0-1.5-2.0 (-3.5)\mu$  cr., verruculosa; poris germinationis non visis. In caulibus Juniperi deppeanae, tumores fusiformes faciens.

Specimens examined, all collected by the author in the San Francisco Mountains in Catron Co., New Mexico: 66-50 (BPI-holotype), Gila National Forest about 8 road-miles south of Luna along U.S. Highway 180, Sec. 31, T. 6 S. R. 20W; 65-60, same place as the preceding; 66-51, Apache National Forest, Blue River-Brushy Mountain road, Sec. 7 or 8, T. 8 S. R. 21 W.

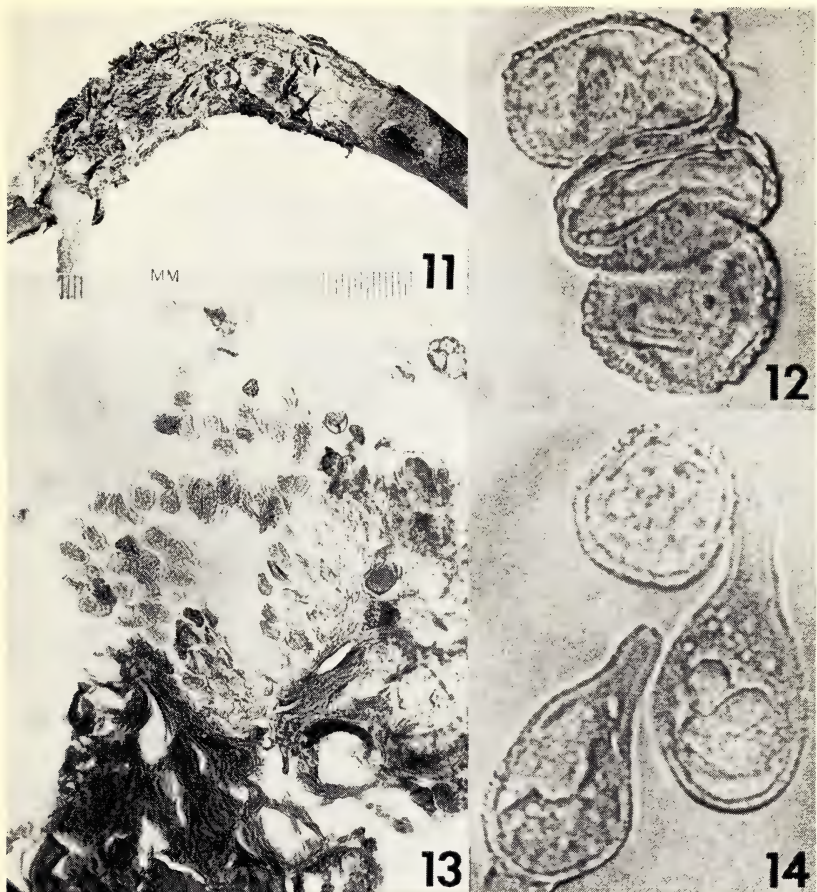
The specific epithet honors a major ethnic group of the area.

*Uredo apacheca* causes conspicuous, fusiform galls on alligator juniper. Old galls become very rough-surfaced, like those described above for *Gymnosporangium speciosum* on the same host.

*Uredo apacheca* was not abundant in either locality where it was studied. One or two trees were heavily infected in each area and resembled the juniper pictured by Cummins (1943) that was infected by *G. ?speciosum*. Other trees in each locality bore only one or two galls. No young infections could be found: the youngest one (fig. 11) is at least 10 years old. The clustering of galls in the heavily infected trees suggests direct juniper-to-juniper transmission of the fungus.

Woody vegetation in both collection localities consisted largely of *Pinus edulis*, *Juniperus deppeana*, *Quercus gambelii*, and *Cercocarpus montanus*. No Pomoideae—the usual aecial hosts of rust fungi on *Juniperus*—were seen.

*Uredo apacheca* is the fifth described fungus with uredinia on Cupressaceae and the first on *Juniperus* sect. *Sabina*, the others being on *J.* sect. *Juniperus*, *Chamaecyparis*, *Heyderia*, and *Cupressus* (Kern, 1964; Peterson, 1967). It is the first species on Cupressaceae reported to have uredinia with peridia or urediniospores borne in chains (figs.



FIGS. 11-14. 11, Gall caused by *Uredo apachea* on *Juniperus deppeana*; 12, peridial cells of *U. apachea*,  $\times 700$ ; 13, a small uredinium and spores of *U. apachea*,  $\times 140$ , overlying bark was cut away in preparing the section; 14, pyriform spores of *U. apachea*,  $\times 720$ .

12, 13). Its urediniospores (fig. 14) scarcely resemble those of any of the other four species. *Uredo apachea* is more similar to another fungus on Cupressaceae, the Japanese species *Caeoma deformans* (Berk. & Br.) Tub. Host reactions to the two differ, but general morphology—large, irregularly shaped spores borne in chains under a weak peridium—are similar. Of all the rust fungi on Cupressaceae, only *U. apachea*, *C. deformans*, and *C. espinosae* Syd. have light-colored spores that lack obvious germ pores. The biggest difference between *U. apachea* and *C. deformans* is that the latter regularly produces spermogonia and is regarded as an aecial state.



There was a possibility that the sori of *U. apachea*, too, might be aecia rather than uredinia, although no spermogonia could be found in the infections. Nuclear constitution of the sorus initials and of the mycelium which produces them provides the critical means of distinguishing the two spore stages. Sections of collection 65-60 were cut at  $15\mu$  in paraffin and stained by Heidenhain's iron alum-haematoxylon technique. Most rust hyphae in the vicinity of the sori and elsewhere were entirely composed of binucleate cells. In hyphae where apparently uninucleate cells were seen there were also binucleate cells, suggesting that the uninucleate appearance was due to artifacts of sectioning and staining. As the mycelium appeared to be dikaryotic, and there were no spermogonia, it was concluded that the sori are uredinia.

The same tissue sections showed that most urediniospores are binucleate, with a minority of trinucleate spores, a few quadrinucleate ones, and possibly a few uninucleate ones.

The same sections plus others from the same specimen, stained in safranin, showed that the hymenium and underlying mass of fungus tissue totaled only  $40-90\mu$  thick except for occasional "pockets" between host cells—these are up to  $160\mu$  thick. Some basal cells appeared to produce more than one chain of urediniospores by lateral budding or branching. Mycelium of the fungus is intercellular throughout the host cortex and in much of the phloem, rarely reaching the cambium, and in the one specimen sectioned mycelium was never observed in the xylem. Hyphae are thick—often as much as  $7\mu$ —and somewhat contorted, therein resembling some species of *Gymnosporangium*. Haustoria are simple, thick, and usually obovoid.

Individual chains of urediniospores in some instances exceeded 50 spores in length. Narrow ends of pyriform spores and "handles" on occasional other spores pointed toward the hymenium, unlike the arrangement in some other species, as *Cronartium comandrae* Pk., with pointed spores. No clear intercalary cells were seen, but thin-walled fungus tissue in the uredinium probably represented intercalary material. The spore mass was usually covered by host bark, with only narrow openings through cracks.

Coloration, a distinctive characteristic for most rust fungi on Cupressaceae, is a puzzling feature in *U. apachea*. Most sori appear to be nearly white, but some are yellowish. Both walls and protoplasts of most spores are hyaline, but there are carotenoid pigments in the protoplasm of some. Spore mounts from the sori that are deepest yellow reveal a different sort of coloration: spore walls and probably spore contents are of a uniform, dingy yellow that seems unlike carotenoid pigment. I did not determine whether this color was native to the fungus or the result of leaching of tannins from the host bark.

Germination of spores from collection 66-50 was tested on 2% water agar. Germ tubes were mostly  $100-150\mu$  long after 24 hours at  $18^{\circ}\text{C}$ . Tubes were  $3-4\mu$  wide and were unbranched or had a few short branches



near their bases. It happened that only colorless spores were included in the test, and their tubes were also colorless.

On the surface of collection 65-60 were a few scattered teliospores that probably belong to a *Gymnosporangium*. None could be found clearly associated with the uredinia, which are therefore described in *Uredo*, with the hope that this description will stimulate more thorough study of the life cycle of this remarkable fungus.

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#### NOTES AND NEWS

STEENS MOUNTAIN.—A paper entitled, 'A botanical excursion to Steens Mountain, SE Oregon, U.S.A.," appeared in the Scandinavian journal *Blyttia* (24: 177-181. 1966). The author is Prof. Knut Faegri, University of Bergen, who spent a portion of the 1965 school year in residence at Oregon State University. Prof. Faegri compares the plant communities observed on Steens Mountain with corresponding ones in the mountains of northern Europe, and outlines his ideas on the major climatic factors affecting alpine plant distributions. Because this journal may not be readily available to botanists in western North America, reprints will be provided on request by the author (Botanisk Museum, Postboks, 2637, Bergen, Norway).—KENTON L. CHAMBERS, Botany Department, Oregon State University, Corvallis.

## A NEW SPECIES OF PTERIGONEURUM FROM CALIFORNIA

HOWARD CRUM

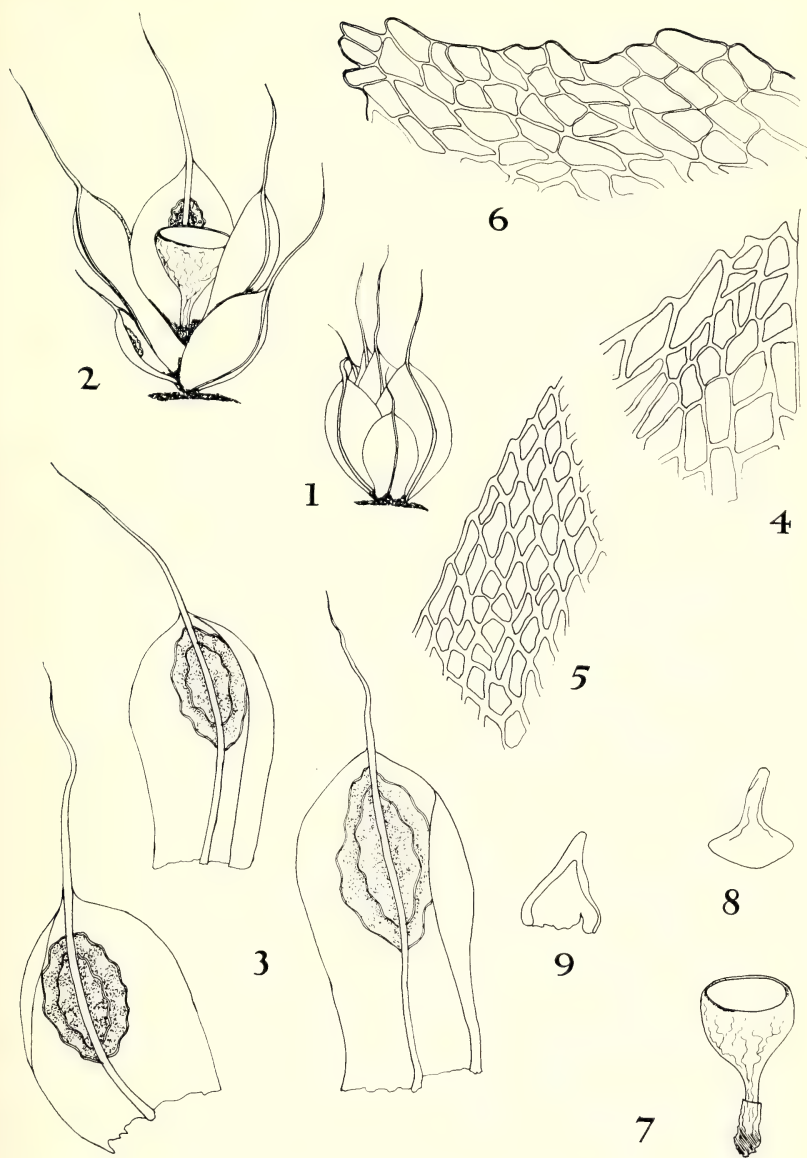
Recently I discovered in the herbarium of the University of Michigan a California collection of a curious *Pterigoneurum* which had been erroneously assigned to *P. subsessile* (Brid.) Jur. Although related to *P. subsessile*, it differs from that species in its compact, bulbiform habit of growth (especially before complete maturity), smooth spores, and cucullate calyptrae. In these and other less tangible characteristics which result in a distinctive aspect, the plants clearly warrant description as a new species.

***Pterigoneurum californicum*** n. sp. Plantae minutae, ca. 1.5 mm altitudine, plus minus bulbiformes, gregariae. Folia incurva et imbricata vel laxe erecta, concava, usque ad 2 mm longitudine, in pilo hyalino usque ad 1 mm terminata, marginibus integris vel superne serrulatis, costa excurrente, cellulis rhomboideis laevibusque. Capsula immersa, subhemisphaerica, sicca et madida irregulariter rugosa, gymnostoma, usque ad 0.8 mm altitudine, operculo conico-rostrato. Sporae 22–29  $\mu$ , sphaericae vel breviter ellipsoideae, brunneae, laeves. Calyptra cucullata et laevis, operculum non exedens.

Plants very small, about 1.5 mm high, bulbiform, becoming more loosely foliate with maturity, dull, yellow-brown, loosely gregarious. Leaves few, incurved and imbricate or loosely erect, keeled-concave, small below, larger above, the upper leaves 1–2 mm long (exclusive of the awn), oblong-ovate, oblong, and oblong-obovate, obtuse, abruptly narrowed to a hyaline, flexuose, somewhat serrulate awn up to about 1 mm long; margins erect, subentire to serrulate near the apex, especially at the base of the awn; costa strong, brown, excurrent into and filling the awn; lamellae on the upper surface of the costa 4, somewhat irregular at the margin; upper cells smooth, irregularly hexagonal to oblong-rhomboidal, about 10–15  $\mu$  wide, 1–2, sometimes 3:1, with thin to rather firm walls not thickened at the corners; basal cells laxly rectangular. Presumably autoicous (antheridia not seen). Setae erect, 0.35–0.5 mm long; capsules deeply immersed, 0.55–0.8 mm long, subhemispheric, yellow-brown, strongly wrinkled (especially when dry); annulus none; operculum stoutly conic-rostrate from a low, convex base, with cells in straight vertical rows; exothecial cells thin-walled; stomata in a single row at the extreme base of the capsule; peristome none. Spores spherical or slightly ellipsoidal, 22–29  $\mu$ , brown, smooth. Calyptra cucullate, smooth, naked, covering only the operculum (figs. 1–9).

Holotype. Alkali flats along Panama Lane 5 miles W of Highway 99 just S of Bakersfield, Kern Co., California, *Leo F. Koch 4026*, January 24, 1952 (MICH.)

The meager specimen at the University of Michigan was received from Tulane University, where Koch once held a teaching appointment.



FIGS. 1-9. *Pterigoneurum californicum*: 1, a rather young plant of bulbiform aspect,  $\times 29$ ; 2, a fully mature plant with leaves somewhat spreading (wet or dry),  $\times 29$ ; 3, three leaves,  $\times 55$ ; 4, cells at base of the awn,  $\times 247$ ; 5, cells somewhat below the awn,  $\times 247$ ; 6, lamella (at its upper end),  $\times 247$ ; 7, capsule,  $\times 29$ ; 8, operculum,  $\times 29$ ; 9, calyptra,  $\times 29$ . I am indebted to Dale H. Vitt for preparation of the drawings.

It is presumed that duplicate specimens may be found there, under the name of *P. subsessile*, and also in Koch's herbarium, which is deposited at the University of Illinois.

The distinctive features of this new species are the deeply immersed, strongly wrinkled capsules, completely lacking a peristome, smooth spores, cucullate calyptrae, and leaf cells without collenchymatous corner thickenings.

Herbarium, University of Michigan, Ann Arbor, Michigan

## REVIEWS

*The Flora and Fauna of Solano County*. Edited by WILMERE JORDAN NEITZEL. viii + 160 pp., illustrated in color. Solano County Office of Education, Fairfield, California. 1965. \$5.00.

The intent of this book is admirable; unfortunately its content leaves much to be desired. There are seven sections dealing with the wild flowers, trees, insects, fishes, amphibians and reptiles, birds, and mammals. Each kind of plant or animal is illustrated by a colored drawing; some bear only a vague resemblance to what they are supposed to represent. Inaccuracies appear in practically every one of the 151 accounts dealing with plants. These range from misspellings, such as "*Eschscholtzia*" (p. 28), to statements that *Heteromeles arbutifolia* has two ovaries (p. 30), to comments that *Collinsia heterophylla* has bulbs which "when boiled yielded a molasses-like syrup which was very popular with the early Indians of this county who used it as a syrup on meal" (p. 14), to the inclusion of *Aconitum columbianum*, a plant which does not occur in Solano County (p. 7), to the manufacture of such nonexistent names as "*Dodecatheon majus*" (p. 28). One can only wish, as Katharine Brandegee did (*Zoe* 1:224. 1890), "that future Boards of Education who would probably employ a carpenter if they wished to build a house, will show their common sense by employing a botanist when they want a local flora."—JOHN H. THOMAS, Dudley Herbarium, Stanford University.

*Atlas of North American Astragalus*. By RUPERT C. BARNEBY. *Memoirs of the New York Botanical Garden* 13:lv + 1-1188, illustrated, in two parts. 1964. Cloth, \$35.00; paperbound, \$30.00. Available from Stechert-Hafner, 31 East 10th St., New York, New York 10003.

This monograph is the culmination of many years of work on a particularly difficult genus of higher plants. Many earlier papers on *Astragalus* by Mr. Barneby appeared under the title of "*Pugillus Astragolorum*," indicating in an indirect way some of the difficulties encountered.

In all, 368 species of *Astragalus* are native in North America: only half a dozen have been introduced. Each species is fully described, synonymy is given, range is stated, good distribution maps are included, representative specimens are cited, and pertinent notes are presented. Illustrations of individual species are not included, but in a work of this length that is probably more than one can expect. Rather than prepare one very long key to all the taxa, Mr. Barneby has written 11 regional keys, a feature that local botanists will find most convenient.

This monograph is based on field and herbarium studies and as such indicates the kind of work that is still necessary in many, many groups before detailed biosystematic investigations can be carried out. Mr. Barneby is to be congratulated for his perseverance and patience in bringing forth this fine treatment.—JOHN H. THOMAS, Dudley Herbarium, Stanford University.



*Systematic Embryology of the Angiosperms.* By GWENDA L. DAVIS. 528 pp. John Wiley and Sons, N.Y., London, Sydney, 1966. \$19.75.

Professor Davis uses embryology in the broad sense of including structures involved in reproduction by seed, such as the entire ovule and anther, the male and female gametophytes, and the embryo and endosperm.

It is pointed out that "far from the descriptive phase of angiosperm embryology being over, it is hardly begun. . . . In the Compositae, for example, although there are over 300 publications, these concern species in only 15% of the genera. . . ." In nearly 20% of the families recognized by Hutchinson there could be traced no information on any embryological structure or process.

Embryological characters useful in systematics and taxonomy are described in the introduction. Considerably more attention is paid to the development of the anther than is usually found in embryological discussions. In the treatment of the ovule, apomixis, adventive embryony, and polyembryony are included.

The second part of the book lists alphabetically the angiosperm families as classified by Hutchinson (1959). Brief references to important embryological works are given for each family, together with a list of the authors. It is unfortunate that, for the larger families at least, the genera on which these authors worked are not mentioned, so that a long search in the bibliography is required.

By far the greatest part of the book consists of a bibliography of some 5000 items dealing with embryological literature.

It is this last feature that makes the book so valuable, not only to plant embryologists and plant breeders, but also to all botanists who have occasion to know what information is available on the embryological aspects of a particular species.

The last comprehensive similar treatment of plant embryology was Schnarf's "Vergleichende Embryologie der Angiospermen" published in 1931. The "Systematic Embryology of the Angiosperms" can now supplant this valuable reference work. Professor Davis is to be heartily congratulated by embryologists for stating the case for the use of embryology in taxonomy, and by all botanists in making available to them such a comprehensive embryological bibliography.—MARION S. CAVE, Department of Botany, University of California, Berkeley.

## NOTES AND NEWS

TERRESTRIAL VASCULAR PLANTS OF AÑO NUEVO I., SAN MATEO CO., CALIFORNIA.—This small, 12 acre island (Orr, R. T., and T. C. Poulter, *Pacific Discovery* 15(1): 13–19, 1962) lies about one-fourth mile off the coast at Año Nuevo Pt. about Lat N 37° 06.5', Long 122° 20' W. It is of interest for several reasons. An historic lighthouse was maintained on the island from 1873 to 1948. Año Nuevo I. serves as a rookery for California sea lions, Steller sea lions, elephant seals, and harbor seals (Orr, R. T., and T. C. Poulter, *Proc. Calif. Acad.*: 32:377–404, 1965) and studies in the population dynamics of a rabbit population introduced between 1948 and 1953 are being carried out by David C. Regnery of Stanford University. The island is now administered through the California Division of Beaches and Parks.

Because of the effect that the animal populations will have, and indeed have had, upon the vegetation, I think it worth while to publish a list of the plants I collected during three visits (May 20, 1963, July 19, 1963, and June 19, 1964) which were made possible through the courtesy of Thomas C. Poulter. With the exception of *Rhus diversiloba* and *MeSEMBRYANTHEMUM chilense*, which I did not collect, my specimens are in the Dudley Herbarium. Nomenclature follows that in my *Flora of the Santa Cruz Mountains of California* (Stanford Univ. Press, 1961) except for Onagraceae.

List of plants: *Achillea millefolium* var. *californica*, *Agrostis californica*, *Amsinckia spectabilis*, *Anagallis arvensis*, *Atriplex californica*, *Bromus marginatus*, *B. maritimus*, *B. rigidus*, *Cakile maritima*, *Camissonia cheiranthifolia* (Spreng.) Raimann, *Cardamine oligosperma*, *Centaurea melitensis*, *Chenopodium californicum*, *Chlorogalum pomeridianum*, *Cirsium occidentale*, *C. vulgare*, *Cotula coronopifolia*, *Daucus pusillus*, *Distichlis spicata*, *Dudleya farinosa*, *Elymus mollis*, *E. triticoides*, *Eriogonum latifolium*, *Eriophyllum staechadifolium*, *Eschscholzia californica*, *Festuca dertonensis*, *Franseria chamissonis* ssp. *bipinnatisecta*, *Gnaphalium chilense*, *Hordeum brachyantherum*, *H. leporinum*, *Linaria texana*, *Lupinus arboreus*, *Malva parviflora*, *Marah fabaceus*, *Mesembryanthemum chilense*, *Microseris bigelovii*, *Monta perfoliata*, *Parapholis incurva*, *Plantago juncoidea* var. *californica*, *Polypogon monspeliensis*, *Rhus diversiloba*, *Rubus ursinus*, *Rumex acetosella*, *R. conglomeratus*, *R. crassus*, *Senecio vulgaris*, *Sagina occidentalis*, *Silene gallica*, *Solanum furcatum*, *Sonchus asper*, *S. oleraceus*, *Spergularia macrotheca*, *Stachys rigida* ssp. *quercetorum*, *Stellaria media*, *Trifolium gracilentum*, *T. microcephalum*, and *T. tridentatum*.

A number of coastal strand plants occur on the adjacent mainland but are absent from Año Nuevo I. Among them are: *Abronia latifolia*, *A. umbellata*, *Castilleja latifolia*, *Convolvulus soldanella*, *Fragaria chiloensis*, *Lathyrus littoralis*, and *Poa douglasii*. Coastal strand vegetation is fragile and does not survive repeated or continual disturbance. The pinnipeds move freely over much of the island and have perhaps either exterminated some strand plants or have prevented them from becoming established.—JOHN H. THOMAS, Dudley Herbarium, Stanford University.

## NEW PUBLICATIONS

*Handbook of the Vascular Plants of the Northern Wasatch*. By ARTHUR H. HOLMGREN. v + 202 pp. National Press, Palo Alto, California. Third Edition. 1965.

*Processes of Organic Evolution*. By G. LEDYARD STEBBINS. xiv + 191 pp. Prentice-Hall Inc., Englewood Cliffs, New Jersey. 1966.

*Trees of Northern Florida*. By HERMAN KURZ and ROBERT K. GODFREY. xxxiv + 309 pp. University of Florida Press, Gainesville. 1962.

*Flora of Southeastern Washington and of Adjacent Idaho*. By HAROLD ST. JOHN. xxix + 583 pp. Outdoor Pictures, Escondido, California. Third Edition. 1963.

*Drawings of British Plants*. By STELLA ROSS-CRAIG. Part XXII. Scrophulariaceae (1). 39 plates. G. Bell & Sons, London. 1966. 11/6d.

*A Checklist of the Vascular Plants of Tonto National Monument, Arizona*. By ROBERT L. BURGESS. *Journal of the Arizona Academy of Sciences* 3:213-223. 1965.

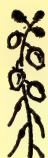
*A Glossary of Terms Frequently Used by Alpine Ecologists and Others*. By JAMES R. HABECK and ERNEST HARTLEY. 29 pp. Available from the authors, Department of Botany, University of Montana, Missoula. 1965.

*A Flora of Wyoming*. By C. L. PORTER. Part III (Cyperaceae-Orchidaceae), 81 pp., Part IV (Poaceae), 88 pp. *Bulletins* 418 and 434, Agricultural Experiment Station, University of Wyoming, Laramie. 1964, 1965.

*A Revision of the Genus Bowlesia Ruiz & Pav. (Umbelliferae-Hydrocotyloideae) and Its Relatives*. By MILDRED E. MATHIAS and LINCOLN CONSTANCE. University of California Publications in Botany 38:vi + 1-73. University of California Press, Berkeley and Los Angeles. 1965.

*Geographical Distribution of the Pines of the World*. By WILLIAM B. CRITCHFIELD and ELBERT L. LITTLE, JR. vi + 97 pp. Miscellaneous Publication 991, Forest Service, U.S. Department of Agriculture, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. 1966.

*Wildflowers of the Monterey Area, California*. By BEATRICE F. HOWITT. 50 pp., illustrated with colored photographs. Wheelwright Press, 975 S. West Temple, Salt Lake City, Utah. Available from the Museum of Natural History, Forest & Central Avenues, Pacific Grove, California. 1965. This spiral bound booklet contains photographs and notes about 63 of the more common kinds of flowering plants of Monterey County.



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## THE SCIENTIFIC WRITINGS OF WILLIS LINN JEPSON (1867–1946)

LAWRENCE R. HECKARD, JOHN THOMAS HOWELL, and RIMO BACIGALUPI

This year marks the centenary of the birth of Willis Linn Jepson and it seems appropriate to commemorate this event by presenting a bibliography of the writings by and about this prolific botanist of California. Although Jepson's publications have never been catalogued, their significance is fully recognized. Keck (1948) states that the "writings of Jepson are both extensive and profound, and they have exerted a lasting influence upon our knowledge of the botany of California." Jepson's botanical writings, spanning 55 years, were exceedingly diverse, ranging from comprehensive scientific volumes to articles in farm journals and newspapers which were aimed at increasing the awareness of the public in matters of conservation, horticulture, or botany. We have included all scientific and biographical writings traceable to Jepson's authorship, many of which are on file in the Jepson Library in the Botany Department at the University of California, Berkeley. Non-botanical writings have not been included here but a listing of these has been placed in the Jepson archives. Other items not included here, such as newspaper articles concerning Jepson or his public addresses, are also in the Jepson archives.

It is timely to announce the availability for scholarly study at Berkeley of the Jepson Correspondence, recently bound in 62 volumes. The letters, covering the period 1887–1946, were arranged and indexed annually under Jepson's supervision. Entries in the indices include personal names, plant names (both scientific and common), place names, and various other categories. Such correspondents are included as: LeRoy Abrams, L. H. Bailey, Katharine Brandegee, Luther Burbank, F. V. Coville, Alice Eastwood, A. Engler, E. L. Greene, John Muir, B. L. Robinson, C. S. Sargent, J. K. Small, as well as many other contemporaries of Jepson.

We wish to thank Joseph and Nesta Ewan and Helen-Mar Beard for their helpful suggestions and for supplying entries for the bibliography.

### OBITUARIES AND HISTORICAL APPRAISALS OF WILLIS LINN JEPSON

1928. CAREW, H. D. The high priest of flora; a glance at the life and works of California's foremost botanist. *Touring Topics* 20(12): 32–34, portrait. [Automobile Club of Southern Calif., Los Angeles].
1933. ANON. The work of Professor Willis Linn Jepson. *Science* 78:597–598.
1938. [Portrait of Jepson. Frontispiece to *Madroño* Vol. 4].

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1947. FRITZ, E. Willis Linn Jepson, a eulogy and a bit of California forestry history, *Calif. Forester* 14:6-8, portrait.
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1947. MASON, H. L. Willis Linn Jepson. *Madroño* 9:61-64.
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1902. A School Flora for the Pacific Coast. D. Appleton & Co., New York, 96 pp.
1909. The Trees of California. Cunningham, Curtis & Welch, San Francisco, 228 pp., 117 figs. Second Edition, Assoc. Students Store, University of California, Berkeley, 240 pp., 124 figs., 1923.
- 1909-43. A Flora of California [incomplete]. 1909: Vol. 1, Part I, pp. 33-64; Part II, pp. 337-368. 1912: Part III, pp. 65-192. 1914: Part IV, pp. 369-464; Part V, pp. 465-528. 1922: Part VI, pp. 193-336; Part VII, pp. 529-578. 1936: Vol. 2, Part I, pp. 1-16, 337-684; Part II, pp. 17-176. Part III, pp. 177-336. 1939: Vol. 3, Part I, pp. 17-128. 1943: Part II, pp. 129-464. [Illus. with 451 figs.].
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- 1923-25. A Manual of the Flowering Plants of California, pp. 33-384 (1923); pp. 1-32; 385-1238 (1925), 1023 figs., 1 map. Assoc. Stu-

dents Store, University of California, Berkeley. Second Printing, 1938. Third and subsequent printings, Univ. Calif. Press, Berkeley, 1951 et seq.

1924. A Flora of the Economic Plants of California for Agricultural Students. Assoc. Students Store, University of California, Berkeley, 223 pp., 16 figs.
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1892. New Californian atriplices. Pittonia 2:303-306.
1893. a. Studies in the Californian Umbelliferae. I, Erythea 1:8-10. II, 62-63.  
b. The mountain region of Clear Lake. Erythea 1:10-16.  
c. [Review of] Sudworth, G. B., On legitimate authorship of certain binomials, with other notes on nomenclature. Erythea 1:123-124.  
d. On a variety of the western sumach [*Rhus trilobata* Nutt. var. *quinata*]. Erythea 1:140-141.  
e. Alien plants in California. Erythea 1:141-143.  
f. Early scientific expeditions to California. I. [La Pérouse Expedition]. Erythea 1:185-190.  
g. The riparian botany of the lower Sacramento. Erythea 1:238-246.
1894. a. Teratological notes. Erythea 2:14-15. [*Dendromecon*, *Eschscholzia*, *Boisduvalia*].  
b. Professor Greene's mission in Europe. Erythea 2:153-155.  
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d. [Review of] Bailey, L. H., Plant Breeding, Erythea 4:143-144.  
e. [Review of] Rusby, H. H., and S. E. Jeliffe, Essentials of Vegetable Pharmacognosy. Erythea 4:144-145.
1897. a. A new west American *Peucedanum*. Erythea 5:1.  
b. Botanical exploration in California in 1896. Erythea 5:7-9.

- c. The new series of Proceedings of the California Academy of Sciences. *Erythea* 5:25–26.
- d. [Note on occurrence of] *Velezia rigida* L. *Erythea* 5:28–29.
- e. The explorations of Hartweg in America. *Erythea* 5:31–35; 51–56.
- f. *Boschniakia strobilacea* Gray. *Erythea* 5:63–66, 2 pls.
- g. [Review of] Howell, T., A Flora of Northwest America. *Erythea* 5:66–68.
- h. Biographical sketch of Dr. W. P. Gibbons. *Erythea* 5:74–76.
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- k. *Carpenteria californica*. *Erythea* 5:124.
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- d. [Review of] Rattan, V., Exercises in Botany for the Pacific States. *Erythea* 6:16–17.
- e. [Editorial comment on] Platt, R. H., *Fritillaria pluriflora* in Solano County. *Erythea* 6:27.
- f. Baron Ferdinand von Mueller. *Erythea* 6:32–35. [Abstract from Victorian Naturalist with editorial comment].
- g. [Editorial comment on] Eastwood, A., Is *Xerophyllum tenax* a septennial? *Erythea* 6:75–76.
- h. *Beckwithia*, a new genus of Ranunculaceae. *Erythea* 6:97–99, 1 pl.
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- j. [Review of] Bailey, L. H., Lessons with Plants. *Erythea* 6:107–108.
- k. [Review of] Barnes, C. R., Plant Life, considered with special reference to form and function. *Erythea* 6:113.
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- f. [Letter on] The California walnut. *Pacif. Rural Press* 75:357.
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## ON THE HORDEUM JUBATUM—H. BRACHYANTHERUM QUESTION

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Rajhathy (1966) disagrees with the separate species status recommended by Mitchell and Wilton (1964) for *Hordeum jubatum* L. and *H. brachyantherum* Nevski. He accepts proof of interbreeding as the overriding criterion for making species determinations; he considers that the above disposition ignores a "mass of evidence" obtained on the interbreeding of these taxa in the Canadian and American West and Midwest. Rajhathy also asserts that the Alaskan work is further invalidated by being based on a "specialized peripheral situation."

Alaska is on the northwestern periphery of the North American range



of *H. jubatum*. The species is nonetheless well adapted to subarctic conditions, occurring frequently and abundantly on disturbances throughout the Interior south of the Brooks Range and in the south-central region transitional to the coast. The propensity of *jubatum* for hybridization appears not in the least affected by Alaskan conditions since it hybridizes frequently with various species (Mitchell and Hodgson, 1965). Alaska hardly can be considered peripheral with regard to the range and adaptability of *H. brachyantherum*. The Alaskan occurrences of *brachyantherum* include much of its principal range along the coastal arc of the Pacific Ocean. The species frequents eastern Asia, is common through the Aleutian Islands and along the coast of Alaska to the panhandle, and extends southward to California. It occurs in well-developed beach meadows, invades disturbed ground, and is a very abundant weed in many Alaskan coastal communities. The species ranges inland along the highway and railway systems of southcentral Alaska. *Hordeum jubatum* and *H. brachyantherum* meet and hybridize in this southcentral region.

Bowden (1962) examined about 160 specimens of *brachyantherum* in the study which led to his combining *jubatum* and *brachyantherum*. Of a total of 82 accessions listed, 50 originated in British Columbia and Alaska, 8 in Alberta, and 2 in Saskatchewan. Moss (1959) stated *brachyantherum* to be "very rare" in Alberta, a plant of saline situations. It is absent in Manitoba (Scoggan 1957) and in areas of Saskatchewan and neighboring United States where the hybrid occurs in abundance (Bowden, 1962; Rajhathy, 1966). Obviously *brachyantherum* prefers the summer-cool and moist coastal region of the North.

Apparently the hybrid is most successful in areas where *brachyantherum* is rare or absent and preserves its identity after migration from its site of origin. In controlled crosses (Rajhathy and Morrison, 1959) even the  $F_2$  plants maintained this identity, remaining "indistinguishable from the  $F_1$  plants," although the  $F_3$  and  $F_4$  plants segregated for awn length (Rajhathy, 1966). Bowden (1962) reported little segregation in  $F_2$  generations that he examined. The hybrid has been recognized by many taxonomists as a variety of *jubatum* (Covas, 1949; Hitchcock, 1950; Scoggins, 1957; Löve, 1959).

In all probability *jubatum* and *brachyantherum* have had a common ancestry (Rajhathy and Morrison, 1959; 1961). But the large amount of morphologic and chorologic differentiation now manifest between the two reflects a successful divergence and reproductive separation effective over a long period of time. The fact that the two produce hybrids on disturbances today is not unusual since *jubatum* hybridizes with numerous species in three or four genera. The production of fertile hybrids is of significance, but it occurs principally in an area that must be considered marginal for *brachyantherum*. Moreover, the effects on the integrity of the *brachyantherum* populations prevalent in this area cannot be ascertained from the data now available.

The increase of the hybrid in the areas where *brachyantherum* is absent must depend on the compatibility of the hybrid with its own kind or with *jubatum*. *Hordeum brachyantherum* cannot be involved in this proliferation. In fact, data from analyses of naturally-occurring, interbreeding populations have not been published from this northern interior area to show that intergrading is indeed taking place. We do not know if backcrossing is occurring, in particular with *brachyantherum*; nor do we know if the ecologically successful hybrid has had any competitive impact on the sparsely-occurring *brachyantherum*. *Hordeum brachyantherum* quite possibly is being eliminated without intergrading with the hybrid.

Our observations and analyses of interbreeding populations (Mitchell and Wilton, 1964) indicate *brachyantherum* is maintaining a separate identity in a substantial portion of its principal range. Such hybridization as occurs in Alaska is not, according to the evidence, producing an incorporation of the gene complexes of *jubatum* and *brachyantherum*. The two species are morphologically distinctive, ecologically at variance except where they meet in disturbances, and for the most part geographically separate as well.

These interpretative differences with the research workers of Ottawa are in no way intended to detract from their excellent cytogenetic and taxonomic work on taxa of the Triticeae.

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## NOTES ON MARINE ALGAE OF WASHINGTON AND SOUTHERN BRITISH COLUMBIA, II

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The following list of algae continues the report on marine algae that have not previously been reported in Washington and southern British Columbia (Norris and West, 1966). Our records supplement the lists of Scagel (1957) and Dawson (1961). All specimens are in the herbarium of the University of Washington and are from the State of Washington unless otherwise indicated.

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### CYANOPHYTA

*Aphanocapsa litoralis* Hansging was collected on the piles of the new wharf at the Friday Harbor Laboratories, San Juan I., July 27, 1965 (Norris 5307). This alga was growing in large gelatinous masses on posts that contained large amounts of creosote. The algae showed no deleterious effects from the creosote. This species has not been previously reported from the Pacific Coast of North America. It was originally described from the Adriatic Sea. (See Geitler, 1930-1932).

*Chlorogloea conferta* (Kützinger) Setchell and Gardner was collected on filaments of *Rhodochorton purpureum* growing on rocks in a shaded area of the upper littoral region at Mt. Dallas Beach, San Juan I., July 2, 1965 (West 312). This species has not been recorded north of San Mateo Co., California on the Pacific Coast of North America (Setchell and Gardner, 1919).

*Dermocarpa hemisphaerica* Setchell and Gardner was found growing with *Chlorogloea conferta* on *Rhodochorton purpureum* Mt. Dallas Beach, San Juan Island, July 2, 1965 (West 336). The previous known range for this species was the coast of central California (Setchell and Gardner, 1919). *D. hemisphaerica* is not clearly distinct from *D. suffulta* which also often grows on *Rhodochorton purpureum*.

*Pleurocapsa entophysaloides* Setchell and Gardner was collected growing on a boulder cliff at the high littoral level just south of Deadman Bay, San Juan I., June 11, 1964 (Norris 4986). Previous records of this species do not list it north of central California (Setchell and Gardner, 1919).

### PHAEOPHYTA

*Myrionema phyllophilum* Setchell and Gardner was found at Mt. Dallas Beach, San Juan I., June 26, 1965, (Norris 5186). This species, which grows on leaves of *Phyllospadix*, has previously been known only from Sitka, Alaska (Setchell and Gardner, 1925).



## RHODOPHYTA

*Goniotrichopsis sublittoralis* G. M. Smith is very similar to *Goniotrichum elegans* in its morphology, but it has numerous small irregularly discoidal chromatophores instead of a single stellate chromatophore with a prominent pyrenoid as in *Goniotrichum*. Previously found only on the Monterey Peninsula, California this species was dredged as an epiphyte on various larger algae at Hein Bank, south of San Juan I., July 13, 1965. Field collected plants were quite scarce in the collection, but it was isolated into unialgal culture and herbarium specimens (*West 397*) have been prepared from the cultured material. Smith (1943) did not observe reproductive structures on his specimens but we have found the species readily reproducing by monospores in our cultures. Monospores appear to be transformed vegetative cells produced in both uniseriate and multiseriate regions of the thalli. When mature, the spores are extruded through the thick sheath.

*Erythrotrichia carnea* (Dillwyn) J. Agardh was collected as an epiphyte on *Ceramium gardneri* from concrete floats at Shilshole Bay Marina, Seattle on October 27, 1964. The species was isolated into unialgal culture and herbarium specimens have been prepared from these cultures (*West 398*). Relatively common as an epiphyte in larger benthic algae in the inland waters of Washington, it is surprising that this species has not been recorded here before this time. Field collected plants and the specimens in culture are morphologically the same as the specimens described from other regions. *Erythrotrichia kylinii*, described by Gardner (1927) as having band-shaped plastids, may be conspecific with *E. carnea* because Kylin (1941) described the plastids in former species as stellate, like those of *E. carnea*. If this characteristic is the same in both species, there appears to be no reason to separate them except for a slight difference in diameter of the filaments. Herbarium specimens of *E. kylinii*, unfortunately, do not seem to be available for comparison with our specimens.

*Acrochaetium densum* (Drew) Papenfuss was originally described by Drew (1928) as an epiphyte on *Spongomorpha mertensii* from San Francisco. Since that time it has not been observed on the Pacific coast of North America, although Nakamura (1944) discovered it as an epiphyte on *Polysiphonia* in Japan. In our collection it is epiphytic on *Polysiphonia brodiaei* (*West 245, 345*) from Lloyd's Boat House, Duwamish Head, Seattle, January 11, 1965 and March 15, 1966. This species with its host may have been transported by marine shipping from California since both are known only from the one location in Washington.

*Kylinia arcuata* (Drew) Kylin was previously reported from Duxbury Reef, Moss Beach (Drew, 1928) and Bodega Bay (Johansen, 1966) in California and only once from Washington (Cape Flattery; Drew, 1928). We have observed *K. arcuata* as an epiphyte on *Polysiphonia brodiaei* from Lloyd's Boat House, Duwamish Head, Seattle, March 15,



1966 (West 347). *Acrochaetium densum* and *Kylinia arcuata* grow on the same host and have certain morphological features in common. Both species were isolated into unialgal culture and monosporangia of both are similar in position and in general morphology. The two species usually can be distinguished by differences in their basal systems, however. *K. arcuata* has a single basal cell whereas *Acrochaetium densum* ordinarily has a system of prostrate filaments arising from two hemispherical cells derived from the original monospore. Occasionally, however, in culture the spores of *A. densum* do not divide to form two hemispherical cells but instead produce erect filaments directly. In these cases the plants are indistinguishable from *Kylinia arcuata*. The basal system of *K. arcuata* shows no modifications, remaining unicellular in all culture conditions tested.

The variation exhibited by *Acrochaetium densum* indicates that use of the basal system morphology may not be entirely reliable as a major taxonomic criterion. Further culture work with other species will disclose more information on this problem.

*Audouinella pectinata* (Kylin) Papenfuss was previously known only from Denmark (Rosenvinge, 1909) and Sweden (Kylin, 1944). Our Identification was based on specimens from culture. One clone now in unialgal culture was obtained from a mixed species culture of plants dredged from Hein Bank, south of San Juan I., Washington, June 10, 1964 (West 399). A second clone was obtained from a specimen of *Ptilota hypnoides* (West 293) collected in the intertidal zone at Glacier Point, Vancouver I., British Columbia, Canada, June 30, 1965. The tetrasporophytes of the clones in culture produce monosporangia and tetrasporangia. Monospores produce new tetrasporophytes. The dioecious gametophytes which develop from the tetraspores have a unicellular base in contrast to the multicellular base of the tetrasporophyte. The gametophytes form monosporangia and sexual structures.

*Rhodophysema georgii* Batters. Uncertainty was expressed in our previous report on this species in our region (Norris and West, 1966) because it often is especially difficult to distinguish *R. georgii* from basal cushions of *Smithora naiadum*. Both species grow on the margins of *Zostera* and *Phyllospadix* leaves, but with close examination one can see a distinct difference between the two species. *Smithora* cushions are large, thick and purplish-black, whereas the thalli of *Rhodophysema georgii* are smaller, thinner and are a more distinct purplish-red color. The most reliable method for distinguishing between these two species is by examination of the chromatophores in the cells. *Smithora* cells contain a single chromatophore that is stellate and may be axial or peripheral in position. *Rhodophysema* chromatophores, on the other hand, are numerous in each cell, peripheral in position and disc-shaped.

*Iridea lineare* (Setchell and Gardner) Kylin has been reported as far north as Cape Mears, Oregon (Doty, 1947). In our collection it was found growing in the intertidal region at the site of the Minnesota Sea-

side Station near Port Renfrew, Vancouver I., British Columbia, July 29, 1964 (Norris 5239). This species is perhaps the most distinctive in the genus as it occurs on the Pacific coast of North America in that several very narrowly cuneate thalli grow from a common holdfast. Most of the other species have a much broader basal part of the blade.

*Antithamnion pygmaeum* Gardner, a species closely allied to *Antithamnion defectum* and occupying a similar habitat, previously had a known range extending from Pacific Baja California (Dawson, 1962) to Cape Arago, Oregon (Doty, 1947). We now record *A. pygmaeum* for two locations in northern Washington: in the sublittoral zone at Hein Bank, Southwest of San Juan I., June 10, 1964, and in the littoral zone at Larabee State Park, South of Bellingham, October 15, 1965 (collected by Maurice Dube). In both cases the plants were discovered growing upon larger benthic algae collected from these sites and placed in culture. Both clones in culture lack the acutely pointed terminal cells of determinate branches found on plants growing in the field. Because of this the cultured specimens appear very much like *A. defectum* which has blunt branch tips in the field and in culture. Several features indicate that the two species are not identical, however. First, hybridization attempts between *A. pygmaeum* and *A. defectum* in culture have not been successful. Second, gland cells of *A. defectum* regularly contain a distinct crystalline body extending longitudinally but the gland cells of *A. pygmaeum* apparently never include this structure. Finally the basal cell of each determinate branch in *A. pygmaeum* has the potential to form an indeterminate branch and often does so. *A. defectum* does not exhibit this tendency in either field collected or laboratory cultured material.

In general the dimensions for vegetative and reproductive structures are smaller in the cultured clones than other authors' data indicate for field collected specimens. Herbarium specimens of male, female and tetrasporic material have been prepared from cultured plants. The Hein Bank clone was assigned the number *West 406* and the Larabee State Park clone the number *West 407*.

*Ceramium gardneri* Kylin is isolated and growing in culture from two collections at Shilshole Bay Marina, Seattle, October 27, 1964 (*West 215*), and September 8, 1965 (*West 334*). Previously this species was not known north of Coos Bay, Oregon (Doty, 1947).

*Hymenena kylinii* Gardner was found growing as one of the dominant intertidal species on the reef at the site of the Minnesota Seaside Station near Port Renfrew, Vancouver I., July 29, 1965 (Norris 5254). Previously this species was collected no farther north than Cape Blanco, Oregon (Doty, 1947). This species seems to be closely allied with *Hymenena flabelligera* and may be only a variant of that species caused by different environmental conditions.

*Cryptopleura corallinara* (Nott) Gardner was known only from Mexico and southern California until 1965 when Dawson reported it in his collections in northern California (Dawson, 1965). In our region

fruiting specimens were found in several localities: dredged at 5–7 fathoms, Partridge Bank, west of Whidbey I., July 6, 1965 (Norris 5196); intertidal at American Camp Beach, San Juan I., July 2, 1965 (Norris 5217); intertidal on the reef at the side of the Minnesota Sea-side Station, near Port Renfrew, Vancouver I., British Columbia, July 29, 1965 (Norris 5256).

#### CHLOROPHYTA

*Pseudodictyon geniculatum* Gardner. Blades of *Cymathere triplicata* collected in the drift at Cattle Point, San Juan I., June 15, 1965 (Norris 5181) have extensive infections of a partially endophytic green alga that seems to be *Pseudodictyon* because of the tendency of the branches to unite to form a net. Unlike the plants described by Gardner, the endophyte in our collection forms a pseudoparenchymatous tissue mostly on the surface of the host. Sporangia may be formed in the pseudoparenchyma as well as by the endophytic filaments. Sporangia in our specimens are from 2 to 4 times larger than the vegetative cells. Biflagellate zoospores were released from the sporangia two days after the collection was made. The zoospores are approximately  $10\ \mu$  by  $5\ \mu$ , ovoid, with an acute flagellar end, with a single band-shaped chloroplast onto which a conspicuous stigma is attached. The flagella are approximately  $1\frac{1}{2}$  times the cell length. The chloroplasts of most of the vegetative cells contain more than one pyrenoid. Gardner (1909) described a single pyrenoid in his specimens of *P. geniculatum* and it may be that our specimens represent a new species in producing pseudoparenchyma. Previously *P. geniculatum* has been collected no farther north than Trinidad Bay, California (Dawson, 1965), although Doty (1947) records a doubtful collection by Gardner at Sunset Bay, Oregon.

*Pseudulvella consociata* Setchell and Gardner was found on shells of *Calliostoma* sp. dredged at Mosquito Pass, Northwest of San Juan I., October 29, 1966 (Norris 5308). The filaments of this alga form a solid encrusting layer on the shells, and the basal system does not penetrate the host shells. One or two pyrenoids may be present in the chloroplasts of apical cells of erect filaments, although most chloroplasts have one. This species has not been previously recorded north of central Oregon (Doty 1947).

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## GOSSYPIUM TRILOBUM: AN ADDENDUM

PAUL A. FRYXELL AND CLIFFORD R. PARKS

Existing knowledge concerning *Gossypium trilobum* (Moc. & Sess. ex DC.) Skov. emend. Kear., has been summarized by Fryxell (1965a). He concluded that this species is distinct from *G. thurberi* Tod. in spite of much nomenclatural confusion, but is more closely allied to the latter than to *G. gossypioides* (Ulbr.) Standl., as was suggested by Phillips (1966). It was noted that the plant unfortunately was not available in any of the living collections of *Gossypium* upon which the extensive experimental work with this genus has been and continues to be based. Some recent attempts to collect living material of this species have been unsuccessful.

On the basis of the distributional data summarized in the previous study, we planned to recollect this species, with the special intention of adding living material to existing *Gossypium* gardens. Accordingly, we visited the Mexican states of Sinaloa, Jalisco, Michoacán, México, Guerrero, and Morelos, where the plant is known to occur. Established populations of *G. trilobum* were eventually found in Michoacán, and both living and preserved specimens were collected. The present communication reports observations on these collections.

This trip was supported by the junior author's National Science Foundation Grant GB3900. The trip was undertaken to collect fresh petal tissues of *Gossypium* spp. for chemotaxonomic analysis from the winter garden at Iguala, Guerrero, Mexico, maintained jointly by the U.S. Department of Agriculture and the National Cotton Council, in cooperation with the Mexican government, and to introduce *G. trilobum* into cultivation. The authors were aided in these collections by Kenneth Montgomery and David L. Dreyer.

*Ecological observations.* The city of Zitácuaro, Michoacán, is situated at an elevation of 1,993 m. A road extends south from Zitácuaro down the valley of the Rio Zitácuaro and across to the valley of its tributary, the Rio Temascaltepec, where it reaches the town of Tuzantla. The Zitácuaro-Tuzantla road descends steadily as it progresses southward. We found populations of *G. trilobum* at km 9 and at km 21, at elevations of approximately 1,800 m and 1,600 m respectively. The km 9 site represents the upper altitudinal limit from which plants of this taxon have been collected. Previous collections (Fryxell, 1965a) have been recorded at altitudes of 800 m to approximately 1,500 m.

The most well-developed specimens grew on a steep rocky slope fully exposed to the sun, in what appeared to be undisturbed vegetation. Although other large bushes and small trees grew on the slopes with the *Gossypium*, they were too scattered to compete directly for light. The hillside also had a good if not dense covering of grasses and forbs, compared to habitats typical for *Gossypium*, which generally are more arid and open.

Other plants of *G. trilobum* were observed growing in the fence row, along the roadside, and at the edges of cultivated fields (i.e., in disturbed situations in dense, weedy, and shrubby vegetation). Some of these specimens had been cut (or grazed) in the past, and thus had a more shrubby aspect. Plants of *G. trilobum*, apparently established at the time of disturbance, appeared able to compete successfully with their weedy neighbors; but whether seedlings of *G. trilobum* can succeed in establishing themselves in such dense vegetation is doubtful. The only seedling found was in bare rocky soil near the edge of the road with no other plants in shading distance. It will be necessary, during the right season, to observe germination and seedling establishment in the field. Comparisons of the disturbed and undisturbed habitats in this regard will permit definite statements concerning the competitive ability of *G. trilobum* seedlings.

The plants of *G. trilobum* described above were growing in a habitat apparently typical for the species, one fully exposed to strong insolation. However, a few plants were found in quite a different habitat. At one side of the road near km 21 there is a canyon several hundred feet deep, with nearly vertical sides that drop down to a stream at the bottom. A trail cut into the side of the canyon wall enables one to descend to the bottom. A few plants of *G. trilobum* were observed on this canyon wall, growing in the shade resulting from a heavy growth of brush and scattered trees, and from the curtailed daylength of the narrow canyon. The original canyon inhabitant, a large and possibly old plant, may have reached its position in the course of a minor landslide. A few young plants were found below the older plant, some nearly to the canyon bottom. Apparently *G. trilobum* has a greater tolerance than most species of *Gossypium* for shading and more ability to withstand crowding.

The plants observed were in the full flush of flowering and had an ample crop of immature fruit in mid-October. Evidently the flowering and fruiting pattern of this species is similar to that of the closely allied *G. thurberi*. The latter species begins flowering abruptly in early autumn and then flowers and fruits heavily and rapidly, maturing a large crop of fruits within two months of the onset of flowering. It is vegetative (or dormant) for the balance of the season. This conclusion agrees with collection dates of flowering specimens cited previously (Fryxell, 1965a).

The origin of the boll weevil (*Anthonomus grandis* Boh.) has puzzled entomologists for some time. It has been suggested that one of the wild cottons of Mexico might prove to be the original host from which these insects later transferred to cultivated cotton. No convincing evidence has yet been put forward in support of this thesis. However, observations have never previously been made on *G. trilobum*, a species that in geographical terms might have played such a role. The plants here discussed were carefully examined for signs of weevil infestation,

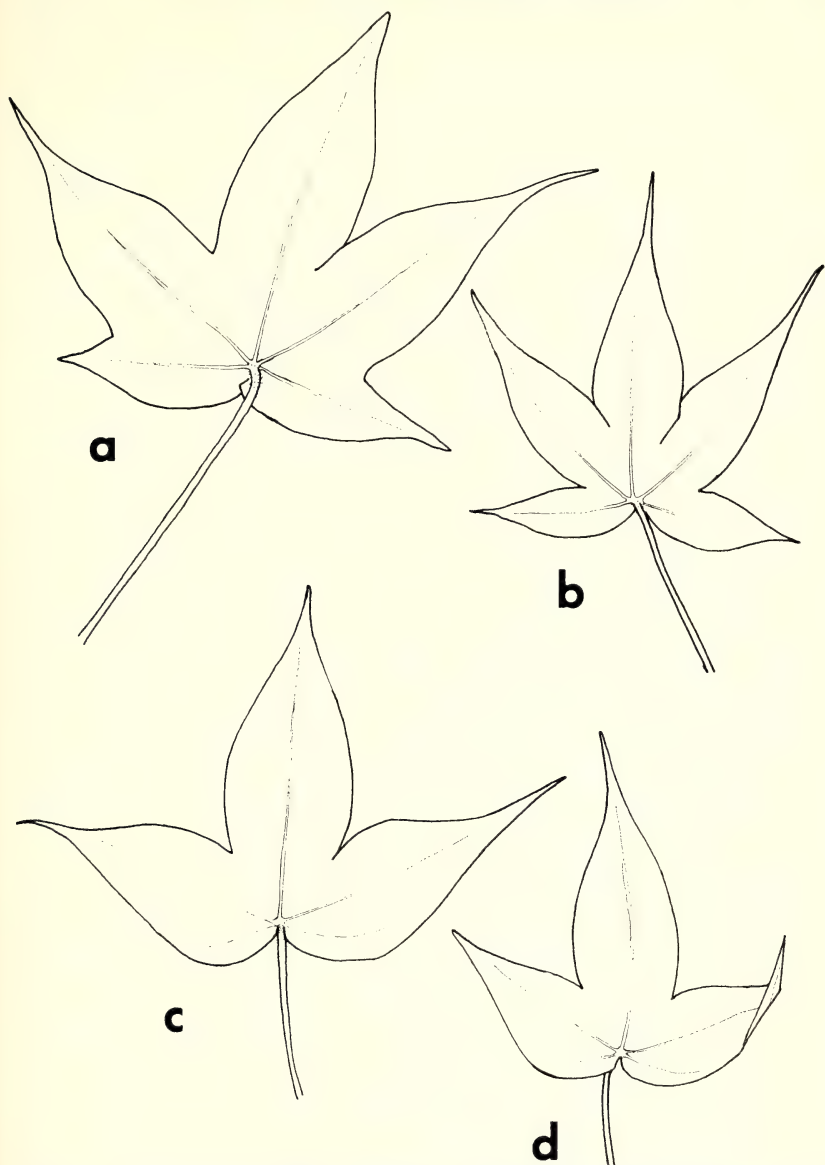


FIG. 1. Leaves of *Gossypium trilobum*, showing the five-lobed form (a, b) typical of the vegetative stalks, and the three-lobed form (c, d) typical of the sympodial flowering branches,  $\times \frac{1}{2}$ .

but none could be detected. This evidence suggests that *Gossypium trilobum* has not played a role as primary host of the boll weevil. Moreover, recent evidence (Fryxell & Lukefahr, 1967) indicates that the primary host may have been found in species of the genus *Hampea* Schlecht.



FIG. 2. Calyx of *Gossypium trilobum* with very young fruit showing distinctive form of margin,  $\times 5$ .

*Morphological observations.* We were able to observe certain features in living plants that are difficult or impossible to observe in herbarium specimens, but which significantly extend our understanding of the species. The plants are large shrubs or small trees, 3 to 4 m in height, with a rounded crown. The trunks of the specimens on the undisturbed slope did not branch for  $\frac{1}{2}$ –1 m above the ground, above which they



branched freely (in contrast to specimens of *G. thurberi* which branch freely at ground level and thus lack a single trunk).

The fruits of *G. trilobum* are predominantly three-loculed, but are rarely two-loculed. No fruits were seen with four locules. The fruits of *G. thurberi* are also predominantly three-loculed, but are occasionally four-loculed.

The involucre bracteoles have been described as cordate-acuminate and entire. This is essentially correct, except that the bracts on one plant (Fryxell 562) were weakly lacinate, rather than strictly entire. Bracts on other specimens showed minute, widely scattered teeth that were not superficially evident.

The leaves are a little more than  $\frac{1}{2}$  cut (fig. 1) on the average. A few leaves were nearly as deeply lobed as is typical of *G. thurberi*, but on the average the leaf dissection in this latter species is much greater than in *G. trilobum*. In both species leaf dissection is variable among the leaves of a given plant, depending on the position and exposure of the individual leaf, but the leaf spectra (Melville, 1953) of the two species are quite distinct. In young plants of the same age grown in culture, leaves of *G. trilobum* are less dissected than those of *G. thurberi*. In *G. trilobum*, climax leaves along the main stalk are typically five-lobed, whereas those occurring on the lateral fruiting branches are generally three-lobed. The specific epithet is derived from the latter type of leaf, since it is more commonly gathered and preserved in herbarium material because of its association with flowers or fruits. Some of the reduced, upper leaves are unlobed and ovate in shape. The foliar nectaries are only sometimes present on climax leaves. They are often but not always present on the trilobed leaves of the flowering branches.

The morphology of the calyx is a distinctive feature of the species (fig. 2). The calyx has been described as having a variable number of irregular divisions (Fryxell, 1965a). Examination of living material has clarified the nature of this structure. The calyx is basically five-lobed, a condition that is characteristic of the balance of the genus (although several species have calyces that are truncate by reduction). During the development of the bud of *G. trilobum*, each calyx lobe splits, generally into two parts, and thus gives rise to a calyx which usually has ten divisions. There is sufficient irregularity in this process, however, that both the number and the size of these divisions are variable. A similar development occurs in no other species of *Gossypium*.

*Gossypium trilobum* has been compared several times with the morphologically similar *G. thurberi* (Kearney, 1937; Fryxell, 1965a). Field observation of the plants confirms this similarity, both authors being already familiar with *G. thurberi* in its native habitat in the Sonoran desert. Specifically, the present observations confirm the hypothesis that these are a pair of vicarious species (Fryxell, 1965b).

*Cytology.* Buds were collected from two plants (Fryxell 562, 563)

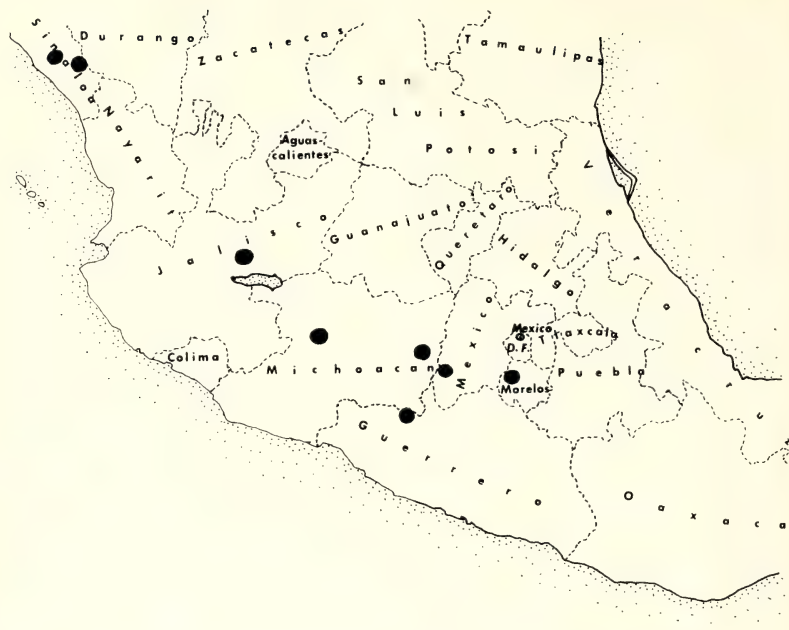


FIG. 3. Map showing known collection sites for *Gossypium trilobum*.

and examined cytologically by Meta S. Brown, Texas A&M University, whose collaboration is gratefully acknowledged. The gametic chromosome number was  $n = 13$ , and the chiasma frequency 1.8 chiasma per bivalent, as determined from the analysis of 926 bivalents from 74 PMC's. A low frequency of quadrivalent association was observed.

*Additional Comments.* Local residents were questioned about the plant, which was well-known to them. The people of the area do not use the plant but call it "algodoncillo" (meaning "little cotton"). They thus recognize its relation to cultivated cotton, even though *G. trilobum* produces no fiber.

By collating information about the distribution of *G. trilobum* (Fryxell, 1965a), the flowering pattern of the species (described above), and the itinerary of the botanists, Sessé and Moçino, who collected the type specimen of this species (Rickett, 1947), one can deduce that the type was probably collected in the autumn of 1790 in central Michoacán, as these collectors traveled from Pátzcuaro to Apatzingan.

The distribution map of *G. trilobum* (Fryxell, 1965a) indicates that the species is fairly widespread, extending more than 500 miles from southern Sinaloa to western Morelos. Yet the species has generally been regarded as rare. A plot of the known collection sites (fig. 3) indicates a concentration in the southern parts of the states of Michoacán and México, in those areas where the elevation provides a suitable habitat

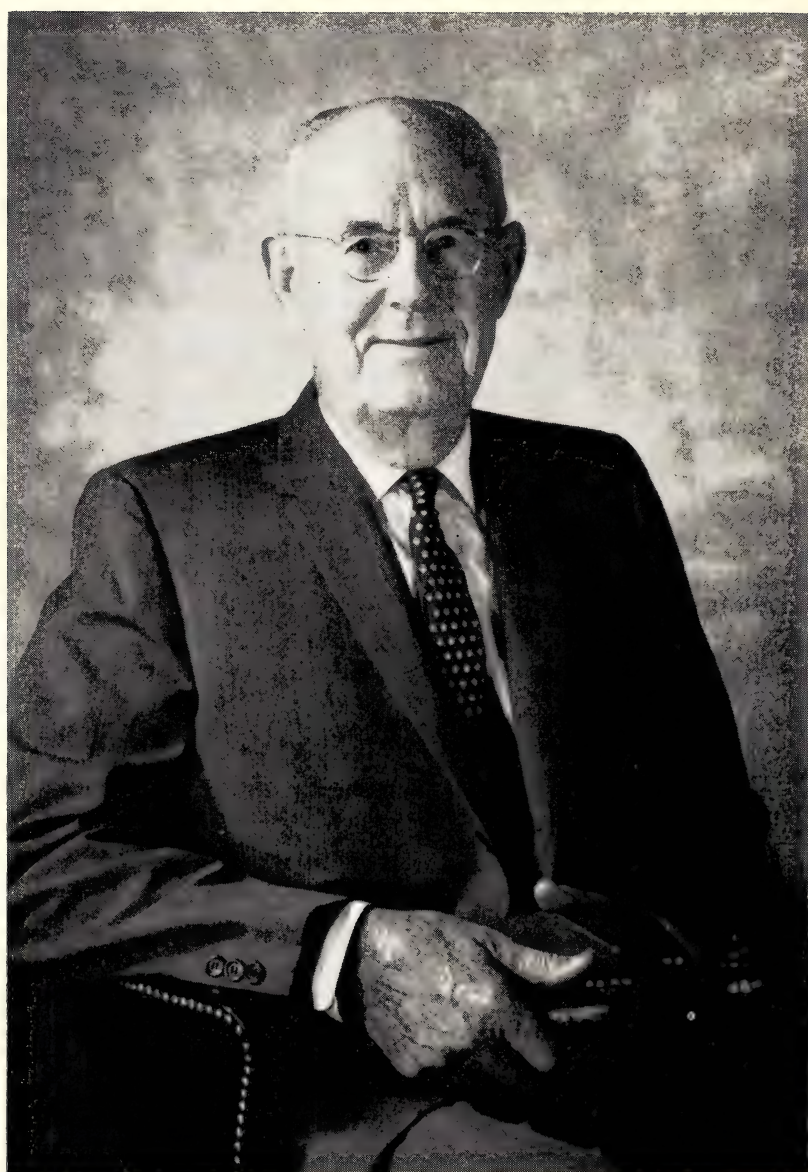
for this species. The region concerned, possibly including the north-western part of Guerrero as well, is one that is not readily accessible by good roads. Perhaps the apparent rarity of this species is consequent on botanists only rarely having penetrated to its native environs. This conclusion is borne out by local informants in the area south of Zitácuaro, where the present collections were made, being quite familiar with "algoedoncillo," and by the specific comment made by one of them that there were many more of the plants to be found in the surrounding hills. *Gossypium trilobum* has perhaps never been rare, only poorly known to botanists.

Herbarium material of *G. trilobum* obtained on the trip described in this paper (Fryxell 562, 563, 564, 565, 567, 568; and Parks 257, 261, 264, 270) will be deposited at the Tracy Herbarium of Texas A&M University (TAES) and at the Herbarium of the Los Angeles State and County Arboretum; duplicates will be distributed elsewhere. The collections were made under a permit granted by the Secretaria de Agricultura y Ganadería, Instituto Nacional de Investigaciones Forestales, México D.F. It is a pleasure to acknowledge the cooperative attitude of that office. Plants of *G. trilobum* have been established at the winter garden at Iguala, Guerrero.

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## LEE BONAR

A tribute to Lee Bonar. We honor your many years of dedicated teaching and your service as Chairman in the Botany Department at Berkeley, your varied and continuous studies on the fungi of California and your long friendship for our Society, which in the past you served as president.

Colleagues who were associated with you in the teaching of general botany, recall with great admiration your ability to interest undergraduates not only in the attractions of the local flora but particularly in a balanced knowledge of *all* aspects of plant life. Your mycological researches extend over more than forty years and have been carried on in both the herbarium and the field. These studies have ranged from ringworm to wood rot, from rusts to sooty molds, from sausage yeasts to poisonous mushrooms and from cankers to witches brooms. Your comprehensive knowledge of the fungi has often seemed to have no end and has always been a source of wonder to your students and colleagues, as well as to the public that has depended upon you so frequently for expert assistance.

Our tribute brings affectionate wishes for your continued good health and for many more years of the quiet but deep satisfaction which you derive from your mycological studies.

## A HYBRID HAWKWEED FROM THE OLYMPIC MOUNTAINS OF WASHINGTON

ARTHUR R. KRUCKEBERG

The subalpine forest type of the Olympic Mountains is not a likely habitat in which to encounter interspecific hybrids. The vegetation typically presents the aspect of a closed community: Open park-like stands of *Abies lasiocarpa* (Hook.) Nutt. (Subalpine Fir) and *Tsuga mertensiana* (Bong.) Sarg. (Mountain Hemlock) form the arboreal setting for the dense growth of grasses and forbs that clothe the intervening subalpine meadows so typical of the upper montane in the Pacific Northwest. As every botanist knows, a species hybrid in such a habitat would be most unexpected. But equally well-known to the field botanist is the effect of disturbance in creating the conditions for crossing.

Thus I was not particularly surprised to encounter a hybrid hawkweed in a disturbed habitat of the upper montane. Along the northeastern flank of the Olympic Mountains in northwestern Washington, U.S.A., the range is buttressed by Hurricane Ridge, a high subalpine hogsback running east and west at approximately 5000 feet elevation. Vegetation patterns are complex along the ridge; exposure and slope change continuously—and abruptly—throughout its length. Basically three vegetation patterns occur here: (1) subalpine conifer forest, (2) upper montane (Hudsonian) meadow on gentle slopes, and (3) the flora of rock outcrops and talus. Midway between the U.S. Park Service lodge on Hurricane Ridge and Obstruction Point to the east, there is an old burn in the meadow-and-forest habitat. A dense cover of grasses and forbs has invaded the site. It was in this situation that on August 1 of 1963 I found two plants which I took to be hybrids between the two very different hawkweeds, *Hieracium albiflorum* Hook. and *H. gracile* Hook. The plants were growing in an open grass-forb swale of what had been a subalpine forest habitat before the fire. The putative parents were in close association with the hybrids (*Kruckeberg 5689 a-e*, WTU). In fact, individuals of both species were included in the sods containing the hybrids; the sods were transplanted to pots and have been in greenhouse and outdoor culture at Seattle ever since.

The probable parents of the hybrids can be easily distinguished both morphologically and by their typical ecological preferences (table 1). *Hieracium albiflorum* is a tall plant of open to deep woods; it has densely pilose basal leaves and tends to be nearly glabrous in the inflorescence. Its ligules are dull white in numerous paniculately disposed heads. In the Olympics, *H. albiflorum* probably reaches its altitudinal limit normally well below the 5000 foot level, and is not usually found on Hurricane Ridge; the species certainly is an unexpected visitor to this habitat. It is not improbable that the plants are adventive on the ridge, as they often occur in abundance after fire or other disturbance at lower elevations.

TABLE 1. MORPHOLOGY, CHROMOSOME NUMBER, AND ECOLOGICAL PREFERENCES OF THE SPECIES AND THEIR HYBRID

	<i>H. albiflorum</i>	Hybrid plants	<i>H. gracile</i>
Basal Leaves	10-12 cm long, 2.0-5 cm wide; often remotely denticulate; pilose (copious above, sparingly below)	12-15 cm long, 1.5-2 cm wide; remotely denticulate; shaggy hirsute, esp. at base, hair mostly long hyaline, erect, some short, green and gland-tipped along margin	2-5 cm long, 0.5-1.0 cm wide; usually entire, nearly glabrous, some pale gland-tipped hairs on margin and midrib
Stem	22-97 (120) cm tall, long, straight tawny-hued hairs below, becoming sparse upward to glabrous in inflorescence	36-64 cm tall; long hairs copious below, sparse upward; hyaline short and matted hairs few to none below, more dense upward to copious in inflorescence (appearing stellate)	5-20 (27) cm high; black, gland-tipped, long hairs mixed with short, hyaline and matted hairs, both more dense upward, esp. long black setose hairs
Inflor-escence	Branches with short, greenish, gland-tipped hairs	Pubescence as on stem	Densely hairy: mixture of matted hyaline hairs and blackish, gland-tipped setose hairs
Involucre	Long stiff hairs usually sparse or absent; copious short, green, gland-tipped hairs	Black hairs moderately dense, of two types: gland-tipped, short and in $\pm$ regular rows; scattered long hairs; hyaline matted hairs mostly at base; pubescence less dense than in <i>H. gracile</i>	Pubescence as in inflor-escence but black hairs more dense (gland-tipped when young); long and short black hairs, or all long and gland-tipped
Ligules	pale white; well exserted	ochroleucous to pale yellow	bright yellow; moderately exserted
Achenes	2.5 mm long, pale brown	—————	2 mm long; blackish brown to black
Pappus	tawny or sordid	—————	dull white
Chromosome Number	$n = 9$ , <i>Kruckeberg 5618d, 5411</i> (Chelan Co.), <i>4393</i> (Clallam Co.)	$n = 9, 5681e$ (two of 186 meiocytes with lagging chromosomes)	$n = 9, 3985$ and <i>5633</i> (Skamania Co.), <i>s.n.</i> (Jefferson Co.)
Habitat Preference	Open to dense coniferous forests; low to middle altitudes; also in disturbed sites	Open grass-forb swales of old burn, Hurricane Ridge, Olympic Mountains, Washington	Subalpine parks and meadows; commonly in closed communities of other grasses and forbs

TABLE 2. POLLEN STAINABILITY AND SEED SET IN SPECIES AND HYBRIDS

	Percent Stainable Pollen*	Number of Seed set
<i>H. albiflorum</i>		
<i>Kruckeberg 5681d</i>	97	high
<i>H. gracile 5681a, c</i>	94, 100 (2 plants)	high
Hybrids		
<i>5681a</i>	27	13 (from 50 heads)
<i>5681e</i>	40-64 (3 heads)	12 (from 46 heads)
2nd Generation hybrid progeny from		
<i>5681a</i>	62, 82 (2 plants)	heads all sterile
<i>5681e</i>	82	30 (from 35 heads)

\* Counts of 200 grains in aniline blue-lactophenol.

The other species, *Hieracium gracile*, is truly at home in the sub-alpine meadow habitat. It is surely as much an indicator of the sub-alpine (Hudsonian) zone in the Pacific Northwest as such ubiquitous grasses and forbs like *Deschampsia atropurpurea* (Wahlenb.) Scheele, *Phleum alpinum* L., *Erigeron peregrinus* (Pursh) Greene, *Veronica cusickii* Gray, and *Luetkea pectinata* (Pursh) Kuntze, to name a few. Typically, *H. gracile* is a much shorter plant (3-35 cm) than *H. albiflorum*. It has nearly glabrous basal leaves; the pubescence of the cauline portions increases upward to a dense mixture of long and short hairs in the inflorescence. The peduncles and involucre bracts are coated with both short, matted hyaline hairs and long, blackish (often gland-tipped) setae; the heads in bud have a distinct grizzled and blackish aspect. Incidentally, though the regional manuals (Abrams and Ferris, 1960; Hitchcock, et al, 1955) describe the short hoary portion of the indumentum as stellate, I could not confirm this observation; rather, the matted aspect of the hyaline hairs often give the hairs a criss-cross pattern which simulates the stellate character. *H. gracile* has bright yellow ligules in fewer, more congested heads, as compared to *H. albiflorum*.

The hybrids are clearly intermediate in the features that distinguish the two putative parents (table 1). Stature, foliage, vesture, number of heads, ligule color, and achenes all manifest the influence of both *H. gracile* and *H. albiflorum*.

Both species have the chromosome number,  $n = 9$ ; and from several samples taken in Washington, I have yet to detect any chromosome irregularities during microsporogenesis. Moreover, both species have "good" (well stained) pollen (table 2). Thus, there is nothing to suggest that the two species are apomictic, a condition commonly en-



countered in other species of *Hieracium* (Stebbins, 1950). The presumed sexuality and the close sympatry of the two species provide the opportunity for interspecific hybridization. The expression of intermediate morphology in the suspected hybrids reinforces the judgment of hybridity.

The plants taken from the wild in 1963 have flowered and produced seed in the greenhouse now through 1966. Both species produce copious and viable seed in cultivation. The presumed hybrid plants produce only about 27–64% stainable pollen (table 2). Their heads mature but yield only a few plump seed (table 2). Healthy progeny have been raised from the few good seed harvested from the original wild hybrids and from the second and third generation hybrid derivatives. The later generation hybrid progeny tend more to perpetuate the intermediate features of the original hybrid than to segregate for the parental characters.

Examination of meiosis in microsporogenesis of hybrids reveals hardly any chromosome irregularity. Of 186 sporads examined, ranging from diakinesis to telophase II, only two cells were observed to have any irregular (lagging) chromosomes.

It would appear that *Hieracium albiflorum* and *H. gracile*, though two distinctly different species, can hybridize in the wild. As the hybrids are not wholly sterile, the gene flow could increase by introgression or be restricted to hybrid swarms. Botanists should expect to find the hybrids and their derivative progeny repeatedly throughout the ranges of the two species, presumably most often under the ecological conditions described above. I have yet to encounter reports of other hawkweed hybrids for western North America. *H. albiflorum* overlaps in range with several other western species; other crosses will undoubtedly be encountered.

Note added in proof. A natural hybrid between *H. albiflorum* and *H. argutum* in Monterey Co., California, has been reported by Anderson and Stebbins (1954).

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# A SURVEY OF THE VASCULAR PLANTS ABOVE TIMBERLINE ON MT. HOOD, OREGON

LUREL HALL

INTRODUCTION. To my knowledge, a survey of the vascular plants above Timberline on Mt. Hood, Oregon, has not been made previously. The colorful old Oregon botanist, Thomas Howell, published the Flora of Mt. Hood in the Mazama's Magazine in 1896 (Howell, 1896) but in this article no differentiation was made between the plants above and below the Timberline. Mr. Howell's article came as a result of previous work done in the Mt. Hood area with Suksdorf, another famous north-west botanist, and subsequently appeared in the records of congress in 1930 as the only available list, although incomplete, of the flora of the Mt. Hood area (Lange, 1953).

The nearly 70 years since Mr. Howell's study have wrought changes as shown by the differences in some of the species found.

GEOGRAPHY. Mt. Hood is situated a little east of the middle of the Cascade range of mountains. It is approximately 22 airline miles south of the Columbia River, 50 miles ESE of the city of Portland, 29 miles SW of The Dalles and 70 miles NW of Bend. Highway access is U.S. 26 from Portland or Bend and by State Highway 35 from Hood River. These two roads form a loop highway on the south and east side of the mountain at an average of 4000 ft. elevation. There is no heavy duty road on the west or north sides but a maze of all weather roads traverses these areas to about 4000 ft. Many improved forest service trails make walking access to many outstanding scenic locations easy and enjoyable.

GEOLOGY. The mountain is situated in a belt of volcanic activity (Wise, 1964) which has been progressing for many years beginning with the extrusion of the Miocene Columbia River basalt over a wide plateau encompassing northern Oregon and southern Washington. Later (about 15 million years ago) olivine basalt and some andesite erupted from many centers throughout the length of the Cascade range building cones up to 6500 feet in elevation. Some of this activity has continued until the present. In recent times (ending about 10 to 15 thousand years ago) the Mount Hood Volcano, through a series of eruptions and extrusions, built the cone. Subsequently, a large glacier formed in the crater, spilled over the south rim, and eroded the south face of the mountain including the major part of the south and southwest rim. Other large glaciers formed at various positions on the mountain eroding the ash and detritus and in places leaving remnants of thicker lava flows. These glaciers have been a major factor in reducing the original cone's height by nearly a thousand feet and creating varied scenery which is unexcelled.

SURVEY LIMITS. A topographic map of the mountain is included with this paper showing general areas and limits of the survey. The exact

limits of Timberline are difficult to pinpoint on a large area such as Mt. Hood. The actual line of demarcation of moderate timber is approximately 6500 feet. This is probably 1000 feet lower than the normal timberline for this climate and general edaphic factors would dictate. The major cause of this discrepancy is the rapid erosion taking place on the surface. Glaciation and running water are moving the mountain away faster than the slowly developing trees can establish themselves. Evidence for this is the fact that the trees are growing at higher elevations on the ridges than in the valleys where major erosion factors are progressing.

Timberline is defined here as the approximate route of the Timberline Trail excepting the White River area and the entire west side where it dips considerably below Timberline to facilitate crossing rugged and dangerous canyons and cliffs. In many specific localities the trail traverses timberlands. Where this occurs the survey includes only the plants above the actual timberline. Three trees, *Tsuga mertensiana*, *Abies lasiocarpa* and *Pinus albicaulis*, are included because their range extended, on many ridges, to over 8000 feet.

METHODS AND RESULTS. Several trips were made to six different areas on Mt. Hood (fig. 1) from July, 1965 through Sept. 1966. Specimens on which this report is based are in the Dudley Herbarium of Stanford University with the exception of that of *Polygonum minimum* which is at Washington State University and was kindly determined by Marion Ownbey. Subsequent collections will probably increase the number of species on Mt. Hood.

Two ascents were made to the summit. These are not included in the general areas because no specimens were taken. These trips were made to find the extremes that any plants were growing, and to search for and collect any that were higher in elevation than the regular areas covered. Both ascents were made up the south side. One of the highest plants found on these trips was a small clump of *Sedum divergens* growing from a crevice in a large andesitic rock at approximately 9500 feet, west of the White River glacier, just below Crater Rock. Interestingly enough, this same species was found blossoming beneath an inch of clear ice on the edge of Eliot glacier, east of Pulpit Rock on the north side of the mountain.

*Spraguea umbellata* was also found at about the 9500 ft. elevation. At this extreme altitude the plant was small and the blossoms were growing right on the ground. *S. umbellata* was not found on the north side of the mountain; however, *Hydrophyllum capitatum* seemed to fill the approximate niche there. *Sitanion hystrix*, *Trisetum spicatum*, *Pentstemon menziesii*, *Juncus parryi*, *Solidago spathulata*, *Anemone drummondii* and *Collomia larsenii* were all found growing at high altitudes. *Lupinus lyallii*, *Phlox diffusa* and *Polygonum newberryi* were some of the most abundant and were distributed over a wide range. The other extreme was *Collomia larsenii*, of which only a few plants were found

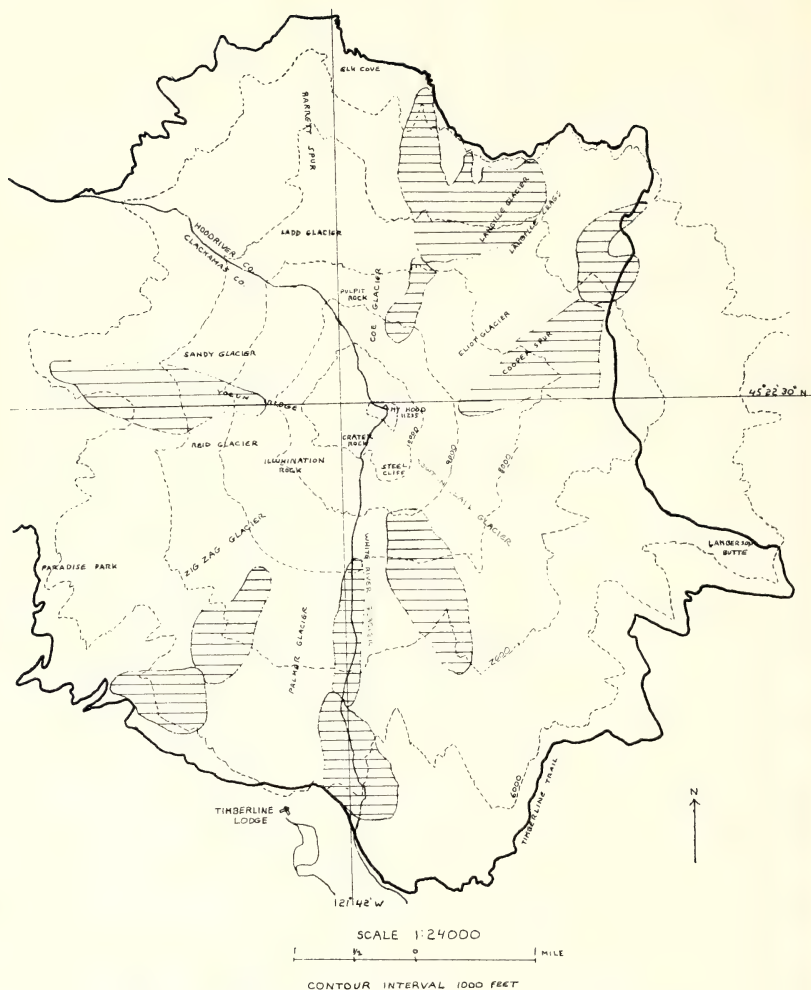


FIG. 1. Mt. Hood, Oregon. Hatching indicates areas collected.

and those were in a very restricted habitat.

Many ecotonal species are included which do not occur at any appreciable distance above the actual timberline. However, if one plant was found on the upper side of the trail, when the trail was distinctly out of the timber, it was included.

In all, the flora consists of 28 families, 56 genera and 82 species. The following list uses the nomenclature and arrangement to be found in Peck's *Manual* (1961).

Pinaceae. *Pinus albicaulis* Engelm., *Tsuga mertensiana* (Bong.) Sarg., *Abies lasiocarpa* (Hook.) Nutt.

Cupressaceae. *Juniperus sibirica* Burgsd.



Gramineae. *Bromus breviaristatus* Buckl., *Festuca viridula* Vas., *F. ovina* L., *Sitanion hystrix* J. G. Sm., *Trisetum spicatum* (L.) Richt., *Deschampsia atropurpurea* (Wahl.) Scheele, *Phleum alpinum* L., *Stipa occidentalis* Thurb., *Agrostis humilis* Vas., *A. diegoensis* Vas.

Cyperaceae. *Elyna bellardii* (All.) Degl., *Carex stramineiformis* Bail., *C. ablata* Bail.

Juncaceae. *Juncus parryi* Engelm., *J. drummondii* E. May., *J. mertensianus* Bong., *Luzula spicata* (L.) DC.

Liliaceae. *Erythronium montanum* Wats., *Calochortus elegans* Pursh.

Orchidaceae. *Spiranthes romanzoffiana* Cham.

Salicaceae. *Salix comutata* Bebb, *S. pennata* Ball.

Polygonaceae. *Polygonum bistortoides* Pursh, *P. newberryi* Small, *P. minimum* Wats., *Eriogonum marifolium* T. & G., *E. ovalifolium* Nutt.

Portulacaceae. *Spraguea umbellata* Torr.

Caryophyllaceae. *Stellaria umbellata* Turcz., *Arenaria obtusiloba* (Rydb.) Fern., *Silene suksdorfii* Robins.

Ranunculaceae. *Anemone occidentalis* Wats., *A. drummondii* Wats., *Ranunculus eschscholzii* Schlecht.

Crassulaceae. *Sedum divergens* Wats., *S. debile* Wats.

Saxifragaceae. *Saxifraga caespitosa* L.

Grossulariaceae. *Ribes acerifolium* How.

Rosaceae. *Sorbus occidentalis* (Wats.) Greene.

Leguminosae. *Lupinus lyallii* Gray, *L. suksdorfii* Robins., *L. alpicola* Hend., *L. arcticus* Wats. var. *subalpinus* (Robins.) C. P. Sm.

Hypericaceae. *Hypericum anagalloides* C. & S.

Onagraceae. *Epilobium hornemannii* Reich.

Umbelliferae. *Lomatium angustatum* (C. & R.) St. John.

Ericaceae. *Phyllodoce empetriiformis* (J. M. Sm.) D. Don, *P. glanduliflora* (Hook.) Cov., *Cassiope mertensiana* (Bong.) G. Don, *Vaccinium membranaceum* Dougl.

Gentianaceae. *Gentiana calycosa* Griseb.

Polemoniaceae. *Phlox diffusa* Benth., *Collomia larsenii* (Gray) Pays., *Polemonium californicum* Eastw.

Hydrophyllaceae. *Hydrophyllum capitatum* Dougl.

Scrophulariaceae. *Penstemon menziesii* Hook., *P. euglaucus* English, *Veronica arvensis* L., *V. alpina* L., *Mimulus lewisii* Pursh, *M. tilingii* Reg., *Castilleja suksdorfii* Gray, *C. hispida* Benth., *C. oreopola* Greenm., *Pedicularis racemosa* Dougl.

Caprifoliaceae. *Lonicera involucrata* (Rich.) Banks.

Valerianaceae. *Valeriana sitchensis* Bong.

Compositae. *Haplopappus bloomeri* (Hook.) Gray, *Solidago spathulata* DC., *Aster alpigenus* (T. & G.) Gray, *A. campestris* Nutt., *Erigeron poliospermus* Gray, *Anaphalis margaritacea* (L.) B. & H., *Antennaria media* Greene, *Achillea lanulosa* Nutt., *Raillardella scaposa* Gray, *Arnica latifolia* Bong., *Senecio triangularis* Hook., *Agoseris alpestris* (Gray) Greene.

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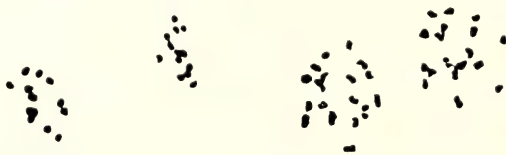
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#### DOCUMENTED CHROMOSOME NUMBERS OF PLANTS

(See Madroño 9:257-258; 17:255. 1964.)

- Astragalus sclerocarpus* Gray.  $n = 11$ . Washington, Adams Co., Sand Dunes State Park. R. Spellenberg 1420, WTU.  
*Bomarea hirtella* (HBK.) Herb.  $2n = 18_{II}$ . Mexico, Chiapas, Municipio of Pueblo Nuevo Solistahuacán. S. S. Tillett 636-3, D.S. Counted by Marion S. Cave. Approximately 5% of the pollen mother cells had 1 bridge with associated fragment, and 1 cell had 2 bridges and fragments, suggesting the presence of two paracentric inversions in this plant. This is apparently the first report of a tetraploid in the genus.  
*Cicendia quadrangularis* (Lam.) Griseb. (*Microcala quadrangularis* (Lam.) Griseb.)  $n = 13$ . California, Contra Costa Co., Richmond, D. M. Post 125, UC; near Giant. D. M. Post 126, UC. The more familiar generic name *Microcala* is apparently invalid due to its being superfluous when published. Fig. 1 shows a microsporocyte at metaphase II of meiosis.



FIGS. 1, 2. 1, *Cicendia quadrangularis*, left; 2, *Exacum affine*, right.

- Cleomella macbrideana* Payson.  $2n = 17_{II}$ . Idaho, Lehmi Co., 12 mi SE of Salmon. G. A. Mulligan and C. Crompton 2961, DAO. Counted by G. A. Mulligan.  
*Eriocaulon compressum* Lam.  $n = 20$ . Florida, Levy Co., near Bronson, I. L. Wiggins 19220, DS. Counted by Marion S. Cave.  
*Eriogonum alatum* Torr. var. *alatum*.  $n = 20$ . Utah, Carbon Co., Tavaputs Plateau. N. H. Holmgren et al. 1961, NY, UTC; Kane Co., Kaiparowits Plateau. N. H. Holmgren et al. 2070, NY, UTC. Counted by J. L. Reveal.  
*E. anemophilum* Greene.  $n = 20$ . California, Mono Co., Sonora Pass. J. L. Reveal & J. A. Reveal 491, UTC. Counted by J. L. Reveal.  
*E. arborescens* Greene.  $n = 20$ . California, San Bernardino Co., Rancho Santa Ana Botanic Gardens, #1560. L. L. Kistler s.n., UTC. Cultivated. Counted by J. L. Reveal.  
*E. caninum* (Greene) Munz.  $n = 12$ . California, Marin Co., Tiburon. D. L. Breedlove 4965, UTC. Counted by J. L. Reveal.  
*E. cinereum* Benth.  $n = 40$ . California, Los Angeles Co., near Malibu. N. H. Holmgren & J. L. Reveal 2616, NY, UTC. Counted by J. L. Reveal.  
*E. compositum* Dougl. ex Benth. var. *compositum*.  $n = 20$ . Oregon, Wasco Co., Tygh Valley. P. H. Raven 18395, UTC. Counted by J. L. Reveal.

- E. covilleianum* Eastw.  $n = 17$ . California, Kern Co., Temblor Range. *E. C. Twisselmann* 13020, UTC; Fresno Co., Warthan Canyon. *E. C. Twisselmann* 13040, UTC; Fresno Co., Los Gatos Canyon, *E. C. Twisselmann* 13311, UTC; San Benito Co., Clear Creek, *E. C. Twisselmann* 13320 UTC; San Benito Co. near Idria. *E. C. Twisselmann* 13350, UTC. Counted by J. L. Reveal.
- E. eastwoodianum* J. T. Howell.  $n = 17$ . California, Fresno Co., Coalinga-Parkfield Grade. *E. C. Twisselmann* 13109, UTC. Counted by J. L. Reveal.
- E. elatum* Dougl. ex Benth.  $n = 20$ . Oregon, Wasco Co., near The Dalles. *N. H. Holmgren & J. L. Reveal* 2116, NY, UTC. Counted by J. L. Reveal.
- E. fasciculatum* Benth. var. *fasciculatum*.  $n = 20$ . California, Ventura Co., near Malibu. *N. H. Holmgren & J. L. Reveal* 2117, NY, UTC. Counted by J. L. Reveal.
- E. flexum* M. E. Jones.  $n = 20$ . Utah, Emery Co., near Ferron. *N. H. Holmgren & J. L. Reveal* 1966, NY, UTC; Garfield Co., near Escalante. *N. H. Holmgren et al.* 2045, NY, UTC; Garfield Co., near Boulder. *N. H. Holmgren et al.* 2122, NY, UTC. Counted by J. L. Reveal.
- E. giganteum* S. Wats.  $n = 20$ . California, San Bernardino Co., Rancho Santa Ana Botanic Gardens, #697. *L. L. Kistler s.n.*, UTC. Cultivated. Counted by J. L. Reveal.
- E. gossypinum* Curran.  $n = 20$ . California, Kern Co., near Hart Park. *E. C. Twisselmann* 13307, UTC. Counted by J. L. Reveal.
- E. gracillimum* S. Wats.  $n = 20$ . California, San Bernardino Co., Lucerne Valley. *N. H. Holmgren & J. L. Reveal* 2594, NY, UTC. Counted by J. L. Reveal.
- E. inflatum* T. & F. var. *deflatum* Johnst.  $n = 16$ . Mexico, Baja California, Angel de la Guarda Island. *R. Moran* 12961. Counted by J. L. Reveal.
- E. jamesii* Benth. in DC. var. *undulatum* (Benth. in DC.) S. Stokes ex M. E. Jones.  $n = 20$ . Mexico, San Luis Potosi, near San Luis Potosi. *D. B. Breedlove* 15468, UTC. Counted by J. L. Reveal.
- E. latifolium* Sm.  $n = 20$ . California, Marin Co., Pt. Reyes. *N. H. Holmgren & J. L. Reveal* 2641, NY, UTC; Sonoma Co., Ocean View, *N. H. Holmgren & J. L. Reveal* 2648, NY, UTC. Counted by J. L. Reveal.
- E. parishii* S. Wats.  $n = 20$ . Mexico, Baja California, near Rancho Marcos. *R. Moran* 13478, UTC. Counted by J. L. Reveal.
- E. racemosum* Nutt.  $n = 18$ . Nevada, White Pine Co., Lehman Creek, Snake Range. *D. B. Breedlove* 5794, UTC; Nye Co., Scofield Canyon, Grant Range. *N. H. Holmgren et al.* 2202, NY, UTC. Counted by J. L. Reveal.
- E. roeum* Dur. & Hilg.  $n = 9$ . California, Tulare Co., Sequoia N. P., *N. H. Holmgren & J. L. Reveal* 2941, NY, UTC; Kern Co., Piute Mts., *N. H. Holmgren & J. L. Reveal* 2943, NY, UTC. Counted by J. L. Reveal.
- E. salicornoides* Gandg.  $n = 18$ . Idaho, Owyhee Co., near Marsing. *N. H. Holmgren & J. L. Reveal* 866, NY, UTC. Counted by J. L. Reveal.
- E. saxatile* S. Wats.  $n = 20$ . California, Los Angeles Co., Tujunga Creek. *N. H. Holmgren & J. L. Reveal* 2613, NY, UTC. Counted by J. L. Reveal.
- E. sphaerocephalum* Dougl. ex Benth. var. *sphaerocephalum*.  $n = 20$ . Washington, Grant Co., near Coulee City. *P. H. Raven* 18493, UTC. Counted by J. L. Reveal.
- E. temblorense* Howell & Twisselmann.  $n = 17$ . California, Kern Co., Temblor Range. *E. C. Twisselmann* 13110, UTC; San Luis Obispo Co., Cottonwood Pass. *E. C. Twisselmann* 13104, UTC. Counted by J. L. Reveal.
- E. thomasi* Torr.  $n = 20$ . Mexico, Baja California, Los Angeles Bay. *R. Moran* 12423, UTC; Angel de la Guarda Island. *R. Moran* 12911, UTC. Counted by J. L. Reveal.
- E. umbellatum* Torr. var. *umbellatum*.  $n = 40$ . California, Alpine Co., near Ebbets Pass. *D. B. Breedlove* 5615, UTC; near Markleeville. *D. B. Breedlove* 5625, UTC; near Monitor Pass. *D. B. Breedlove* 5627, UTC; Idaho, Boise Co., near Banks. *P. H. Raven* 18521, UTC. Counted by J. L. Reveal.

- E. vestitum* J. T. Howell. **n** = 17. California, Fresno Co., near Mercey Hot Springs. *E. C. Twisselmann* 13359, UTC; San Benito Co., near Idria. *E. C. Twisselmann* 13349, UTC. Counted by J. L. Reveal.
- Exacum affine* Balf. f. **n** = 18. Cultivated plant from Missouri Botanical Garden. *D. M. Post* 208, UC. Fig. 2 shows a microsporocyte at metaphase II of meiosis.
- Fagonia laevis* Standl. **n** = 10. Mexico, Baja California, near Cerro Blanco. *I. L. Wiggins & J. H. Thomas* 142, DS. Counted by D. M. Porter.
- Gentiana calycosa* Griseb. **n** = 13. California, Tulare Co., Mineral King. *D. M. Post* 280, UC.
- Hackelia cinerea* (Piper) Johnst. **2n** = 48, **2n** = 24<sub>II</sub>. Washington, Chelan Co., near Cashmere. *R. Spellenberg* 1405, WTU.
- Holcantha emoryi* Gray. **2n** = 26. Arizona, Maricopa Co., Progeny of *D. Verity* in 1966, LA. Counted by P. H. Raven.
- Hypericum formosum* HBK. var. *scouleri* (Hook.) Coul. **2n** = 8<sub>II</sub>. California, Tuolumne Co., near Pinecrest. *P. H. Raven* 20807, DS. Counted by D. W. Kyhos.
- Idahoia scapigera* (Hook.) Nels. & Macbr. **n** = 8. Washington, Kittitas Co., near Ellensburg. *R. Spellenberg* 1637, WTU.
- Orontium aquaticum* L. **n** = 13. Florida, Alachua Co., near Gainesville. *I. L. Wiggins* 19457, DS. Counted by Marion S. Cave.
- Panicum capillare* L. var. *occidentale* Rydb. **2n** = 9<sub>II</sub>. Idaho, Custer Co., Sunbeam Hot Springs. *R. Spellenberg* 317, WTU; California, Shasta Co., near Castle Crags. *R. Spellenberg* 1603, WTU.
- Penstemon gairdneri* Hook. **n** = 8. Washington, Douglas Co., Moses Coulee. *R. Spellenberg* 1400, WTU.
- Schoenocaulon dubium* (Mich.) Small. **2** = 8<sub>II</sub>. Florida, Alachua Co., Gainesville. *I. L. Wiggins* 19866, DS. Counted by Marion S. Cave.
- Smilacina flexuosa* Bertol. **2n** = 36. Mexico, Chiapas, Municipio of Pueblo Nuevo Solistahuacán. *S. S. Tillett* 636-5, DS. Counted by Marion S. Cave.
- Taegetes filifolia* Lag. **n** = 12. Ecuador, Quito. *C. B. Heiser* 6123, IND. Counted by R. T. Neher.
- T. micrantha* Cav. **n** = 12. Mexico, Jalisco, 70 mi N of Guadalajara. *R. T. Neher* 1272, IND.
- T. multiflora* HBK. **n** = 12. Ecuador, Prov. Pichincha, near Pifo. *C. B. Heiser* 5099, IND. Counted by R. T. Neher.
- T. subulata* Cerv. **2n** = 24. Mexico, Durango, 90 mi W of Durango. *R. T. Neher* 1262, IND.
- T. terniflora* HBK. **2n** = 48. Peru, Cuzco. *C. B. Heiser* 6241, IND. Counted by R. T. Neher.
- Tribulus cistoides* L. **n** = 6. Jamaica, St. Catherine, near Caymanas Park. *D. M. Porter* 1024, DS, GH, IJ; St. Andrew, St. Benedict's School. *D. M. Porter* 1037, DS, GH, IJ; Columbia, Atlantica, Barranquilla. *D. M. Porter* 1117, COL, DS, GH; Mexico, Colima, near Tecoman. *D. M. Porter* 1483, GH, MEXU.

## NOTES AND NEWS

XI INTERNATIONAL BOTANICAL CONGRESS—The XI International Botanical Congress will meet in Seattle, at the University of Washington from August 24 to September 2, 1969. Meetings of the Nomenclature Section will be held on August 21-24. Papers and symposia will be given in nine sections: molecular, metabolic, structural, developmental, genetical and cytogenetical, environmental and evolutionary, systematic, ethnobotany, and historical botany. Pre- and post-Congress scientific field trips are planned. The first circular has already been issued and may be obtained from Dr. Richard S. Cowan, Secretary, XI International Botanical Congress, Smithsonian Institution, Washington, D.C. 20560.



## VARIATION IN THE DIPLOID GOSSYPIUM SPECIES OF BAJA CALIFORNIA

LYLE L. PHILLIPS AND DUNCAN CLEMENT

The approximately 30 wild diploid ( $2n = 26$ ) species of *Gossypium* occur in desert and steppe regions of the tropics and subtropics. Most of them are represented in experimental cultures and collectively have been the subject of considerable cytogenetic research. However, the ultimate source of seed for each of the diploid taxa can be traced to only one or two original collections and very little information is available on their morphological and genetic variability.

One of the two largest groups in the genus, in terms of number of taxa, occurs in the Americas from Peru and the Galapagos Islands to Mexico and Arizona. The center of known diversity for this geographically and cytologically defined (D genome) assemblage of species is in western Mexico, where seven of the nine taxa are found. Three taxa, *G. klotzschianum* Anderss. var. *davidsonii* (Kell.) Hutch., *G. armourianum* Kearney, and *G. harknessii* Brandeg., are found in Baja California del Sur (fig. 1). Variety *davidsonii* also occurs in the vicinity of Guaymas, Sonora, Mexico.

In January and February of 1963 we spent approximately one month in the southern half of Baja California del Sur, making field studies and seed collections of *G. klotzschianum* var. *davidsonii* and *G. harknessii*. Seeds of *G. armourianum*, a species of northeastern Baja California del Sur, were collected by Duncan M. Porter of Harvard University. Plants from these seed collections were established and studied at the University of the West Indies, Kingston, Jamaica, and at Raleigh, North Carolina. Herbarium specimens from the University of California, Stanford University, the California Academy of Sciences, and the U.S. National Herbarium were also studied. Recent collections of herbarium material of var. *davidsonii* from the northern part of its range (an area we did not bontanize) were made available to us by Miss Annetta Carter of the University of California. Contribution from the Crop Science Department, North Carolina Agricultural Experiment Station, Raleigh, North Carolina. Published with the approval of the Director of Research as Paper No. 2322 of the Journal Series. Aided by grant G-14203 of the National Science Foundation.

The variation listed and discussed below for each taxon involved in this study is subdivided into "continuous" and "discontinuous" groupings. To some extent this categorization is arbitrary and intuitive, e.g., variability for characteristics such as capsule loculus number, which varies within as well as between individuals and presumably is polygenically controlled, is classed as continuous variation. Variability that can be graded on an absolute scale, e.g., gland red vs. gland colorless, is assumed to be simply inherited and is classed as discontinuous variation. However, a majority of the variation classed as discontinuous has



FIG. 1. Distribution of *G. armourianum* (x), *G. harknessii* (closed circles), and *G. klotzschianum* var. *davidsonii* (open circles) in Baja California.

been thus categorized on the basis of monofactorial  $F_2$  or testcross segregation frequencies of appropriate  $F_1$  hybrids, and most of the variation described as continuous is so categorized because of blurred segregation patterns resulting from these breeding tests.

## TAXONOMY AND VARIATION

GOSSYPIUM KLOTZSCHIANUM Andersson var. DAVIDSONII (Kellogg) Hutchinson, *Evol. Goss.* 22. 1947. *Gossypium davidsonii* Kellogg, *Proc. Calif. Acad.* 5:82. 1873 Type: Cape San Lucas, Baja California, *Xantus 12* (US!). *Gossypium davidsonii* var. *sonoricum* Mauer, *Origin and Sys. Cot.* 256. 1954. Type: Guaymas, Sonora, Mexico, Azerbaijan Cot. Res. Inst. 1562. *Gossypium davidsonii* var. *lobulatum* Mauer, *Origin and Sys. Cot.* 256. 1954. Type: San José del Cabo, Baja California, Mexico, Azerbaijan Cot. Res. Inst. 3552.

Diffusely branched shrub 1–3 m high; young stems punctate with reddish glands, strigose to tomentose with simple and stellate hairs, rarely glabrate; old stems sparsely strigose to glabrous; sympodia 2–5 jointed, rarely 6–12 jointed; leaves entire to 3-lobed, sub-oricular to ovate in outline, cordate at base, acuminate at tip, 5–10 cm long, strigose to tomentose on both surfaces, rarely glabrous, with nectary on abaxial surface of mid-vein, lamina and petiole punctate with reddish glands; stipules small, linear, early caducous; bracteoles cordate, 2–4 cm long, with 6–13 acuminate to obtuse teeth on upper margin; corolla cup-shaped, the petals yellow, usually with small dark-red spot near claw, occasionally spotless; androecium 15–20 mm long, the filaments 2–4 mm long; styles 5–15 mm long, stigmatic from tip to juncture with androecium; capsules 3–5 locular, spherical to fusiform, 15–20 mm long, 10–20 mm wide, usually mucronate, punctate with reddish glands, the sutures ciliate; seeds brown to black, angularly turbinate, with a sparse coating of appressed hairs except on conspicuous raphe.

Distribution. Sea level to ca. 400 m, in open situations, or as an element of thorn-scrub vegetation from extreme tip of Baja California north to vicinity of Bahía de la Concepcion (Lat 26.5°), including off-shore islands in the Gulf of California (Isla Cerralvo) and in the Pacific Ocean (Isla Magdalena) (fig. 1).

Hutchinson (1947) included the Revillagigedos Islands in the distributional range of var. *davidsonii*. For reasons previously detailed by Moran (1961), this is an error.

The type variety of *G. klotzschianum* is endemic to several islands of the Galapagos Archipelago. Variety *klotzschianum* and var. *davidsonii* are morphologically similar, and their hybrid is easily synthesized and fully fertile. The distinguishing features of the two varieties are quantitative rather than qualitative, i.e., var. *klotzschianum* has larger leaves, bracteoles, flowers, etc., than var. *davidsonii* and var. *klotzschianum* develops into an open shrub whereas var. *davidsonii* is usually a compact bush.

The widely disjunct distributions of var. *klotzschianum* and var. *davidsonii* must be explained on the basis of relatively recent trans-oceanic dispersal and Phillips (1966) has argued that the closer phyletic affinity of the two *G. klotzschianum* varieties to Mexican species than to the South American species (Peru) indicates that the dispersal was from north to south.

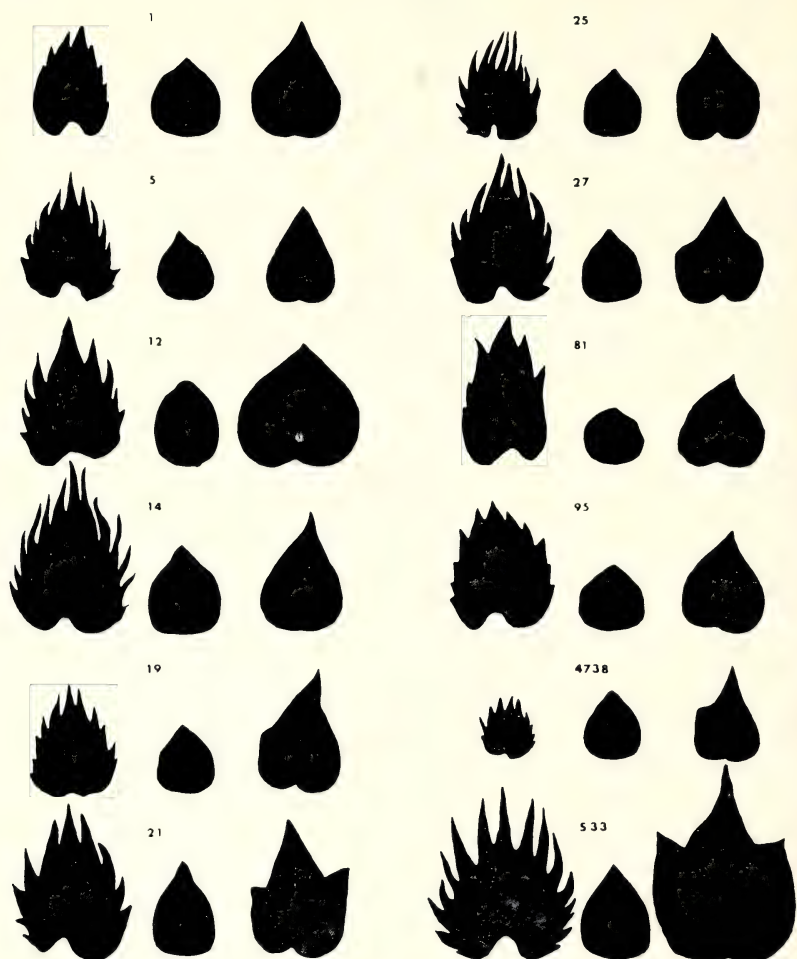


FIG. 2. Bracteole, capsule, and leaf outlines for representative accessions of *G. klotzschianum* var. *davidsonii* (1 through 4738) and one accession of *G. k. klotzschianum* (S 33). Bracteole and capsule,  $\times \frac{1}{2}$ ; leaf,  $\times \frac{1}{6}$ .

Mauer (1954) recognized *G. davidsonii* as a species and described the varieties *sonoricum* and *lobulatum*. Variety *sonoricum* is based on a specimen with entire leaves and 4-locular capsules; var. *lobulatum* is based on a specimen with lobed leaves and 5-locular capsules. Both leaf shape and capsule loculus number are variable throughout the range of var. *davidsonii*, and we regard these two epithets as synonyms of var. *davidsonii*.

Major variation for *G. klotzschianum* var. *davidsonii* is as follows:



### *Continuous Variation*

Pubescence. The entire plant is typically covered with simple and stellate hairs, though these are semi-caducous on the stems. Our collections ranged from sparingly strigose to canescent. A collection by M. E. Jones (24210; US, CAS) is remarkable in being completely glabrous.

Leaf, Capsule, and Bracteole. Variation for leaf, capsule, and bracteole characteristics in var. *davidsonii* is shown in Fig. 2. A majority of those accessions with lobed climax leaves were collected along the south-eastern coast of the Cape region.

Capsule loculus number for var. *davidsonii* ranges from 3 to 5. The average loculus number for the accessions of our study collection is 4.13 per capsule (computed on 10 capsules per accession), the extremes being 3.8 and 4.8.

Sympodial nodes. The number of sympodial nodes for a majority of our accessions ranges from 2 to 5 and averages about 4. The sympodial node number for two accessions is outside this range; in one collection it ranges from 4 to 8, in the other from 8 to 12.

### *Discontinuous Variation*

Anthocyanin coloration. The stems and petioles of var. *davidsonii* are typically "sun-red" owing to a moderate accumulation of anthocyanin; this coloration is most intense at the juncture of the petiole and leaf lamina (pulvinus). In approximately one fourth of the plants grown from one of our accessions the stems and petioles are completely green; the  $F_2$  progenies of crosses between red and green individuals segregated approximately 3 red : 1 green. Apparently the green individuals are conditioned by recessive alleles at a single locus, and presumably the plant from which this seed accession was obtained was heterozygous for this locus.

Foliar nectary. Variety *davidsonii*, and most other *Gossypium* diploids, characteristically have leaf nectaries near the pulvinus on the mid-vein. All of the plants grown from two seed collections lack the nectaries.  $F_2$  progenies of hybrids between plants of these accessions and plants with normal foliar nectaries segregate for presence and absence of foliar nectaries in proportions that provide a satisfactory fit to a 3 nectary : 1 nectariless ratio; it is assumed that nectariless is conditioned by recessive alleles at one locus.

Petal spot. The petals of var. *davidsonii* typically have a red spot, 3–7 mm in diameter, near the claw. One collection lacks this petal spot, and  $F_2$  progeny tests of appropriate hybrids indicate that spotless is simply inherited and recessive.

Pigment glands. The aerial portions of all species of *Gossypium* possess conspicuous glands which contain, among other constituents, gossypol. The capsules of var. *davidsonii* normally have 250–300 glands and the dry weight leaf content of gossypol is 1.8–2%. One of our accessions has a markedly reduced number of capsule glands (60–75) and the

leaf gossypol level is reduced to 0.25%.  $F_2$  progeny tests involving hybrids between this accession and normally glanded individuals indicate a simple recessive genetic model to explain gland and gossypol reduction, though only one locus of a probable two-locus control of gland production is involved.

*GOSSYPIMUM HARKNESSII* Brandegee, Proc. Calif. Acad. 2:136. 1889. Type: Santa Margarita Island, Baja California, Mexico, *Brandegee s.n.*, March 1, 1889 (US!). *Gossypium californicum* Mauer, Proc. Central State Univ. Tashkent, 18:21. 1950. Type: Cerro Colorado to Rodriguez, Baja California, Mexico, *Nelson & Goldman 7328* (US!).

Spreading to erect shrub 1–3 m tall with branches semi-decumbent and crooked to ascending and nearly straight; young stems puberulent, punctate with dark-red glands; old stems with conspicuous transversely elongated lenticels; sympodia usually 1-jointed, occasionally 2-jointed; leaves entire to shallowly 3-lobed, orbicular in outline, cordate at base, obtuse at tip, 5–7 cm long, glabrate on adaxial surface, puberulent on abaxial surface, the nectary on abaxial surface of mid-vein often vestigial, occasionally absent, lamina and petiole punctate with dark-red glands; stipules small, linear, caducous; bracteoles 1–3 cm long, entire or with 1–4 acuminate teeth at apex, caducous at anthesis; corolla cup-shaped, the petals yellow with small dark-red spot near claw; androecium 10–15 mm long, the filaments 4–6 mm long, the lowermost pigmented red; styles 3–4 cm long, sparsely ciliate, stigmatic only near tip; pollen usually yellow, occasionally cream; capsules nearly spherical, 15–20 mm in diameter, 3–4(–5) locular, punctate with dark-red glands, the sutures ciliate; seeds brown, 8–10 mm long, with a sparse coating of appressed hairs except on conspicuous raphe.

Distribution. From Lat 23.8° north to Lat 26.1°, including Isla Santa Margarita in the Pacific Ocean and Isla del Carmen, Isla Coronados, and Isla Monserrate in the Gulf of California (fig. 1).

Mauer (1950) distinguished *G. californicum* (the type specimen is from Isla Santa Margarita) from *G. harknessii* on the basis of its lobed leaves and beaked capsule. These two characteristics vary greatly throughout the range of *G. harknessii*, and we consider *G. californicum* to be a synonym of *G. harknessii*.

Major *G. harknessii* variability is summarized below:

#### *Continuous Variation*

Leaf, Capsule, and Bracteole (fig. 3). The *G. harknessii* leaf shape ranges from entire to moderately lobed; the former condition predominates in the northern part of the distributional range and the latter in the south.

Variation for capsule size and shape is slight; however, variability in locule number is evident and geographically correlated. Locule number for those accessions from the southern part of the range is rather consistently 3, rarely 4. Accessions from Loreto and the offshore islands

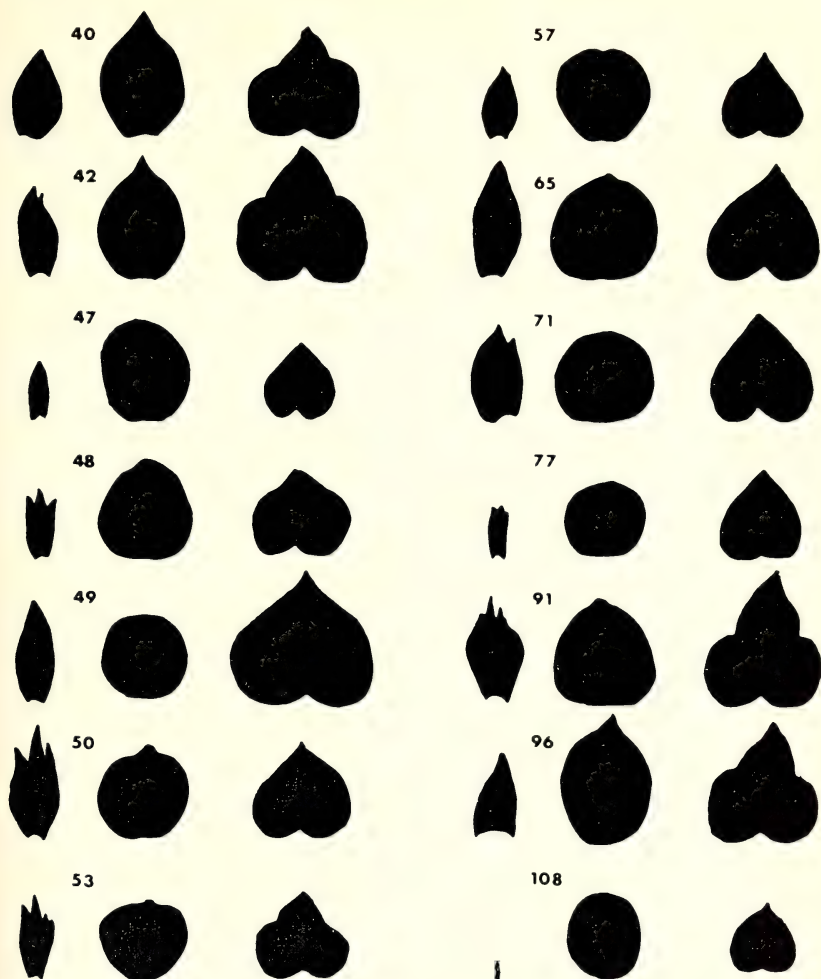


FIG. 3. Bracteole, capsule, and leaf outlines for representative accessions of *G. harknessii* (40 through 96) and one accession of *G. armourianum* (108). Bracteoles and capsules,  $\times \frac{2}{3}$ ; leaves,  $\times \frac{1}{3}$ .

generally range from 3.2 to 3.5 (based on 10 capsules per accession); the capsules of an accession from Isla del Carmen average 3.9, and this accession has the only 5-locular capsules observed in the species (2 of 10).

**Foliar Nectary.** The foliar nectary is vestigial (non-flowing) to absent in *G. harknessii* and variation for these two extremes is observed between accessions, between plants of the same accession and even between leaves of the same plant.

**Sympodial nodes.** The sympodium of *G. harknessii* is typically single-jointed; one accession, however, produced some 2-noded sympodia.



*Discontinuous Variation*

Pollen color. Among a preponderance of accessions characterized by yellow pollen, there are 5 accessions, from all mainland and insular segments of the range, with cream pollen.  $F_2$  progeny tests involving three of these cream pollen mutants indicate that cream pollen is controlled by a monofactorial recessive.

Plant habit. As has been noted previously by Miss Annetta Carter (personal communication), there is an ecotype on Isla Coronados with a combination of characters not present in other populations. This ecotype has a low semi-spreading habit, thick, crooked branches and entire leaves. This complex of characters is suggestive of *G. armourianum* but other morphological features are those of *G. harknessii* (puberulent stems and petioles, long bracteoles, relatively large, deeply cordate leaves).

Non-flaring Capsule. The carpels of the *G. harknessii* capsule are normally fully reflexed, and the seeds are dispersed within a few days following capsule dehiscence. A frequent variant found on Isla Coronados is a type in which the carpels of dehiscent capsules are only moderately reflexed and from which the seeds escape over an extended period of time.

It is of interest to note that *G. harknessii* and *G. armourianum* are the only American diploids that do not have hard, impermeable seed coats; "hard" seed is presumably a device that tends to prevent seed germination when the soil moisture level is insufficient for seedling establishment. A mechanism that would "meter" the dispersal of water-permeable seeds to the substrate, and thereby protract the commitment of seeds to possible germination over an extended period, would have an adaptive significance similar to that of "hard" seed.

GOSSYPIMUM ARMOURIANUM Kearney, Jour. Wash. Acad. 23:558. 1933. Type: Seeds from San Marcos Island, Baja California, Mexico; grown at Palm Springs, California, Kearney, August 25, 1933 (US!).

Spreading shrub 1-2(-3) m tall with decumbent to semi-erect branches; young stems glabrous, punctate with dark-red glands; old stems slightly furrowed, with obscure, circular lenticels; sympodia usually 1-jointed, occasionally 2-jointed; leaves entire, 2-4(-5) cm long, cordate to round-ovate, glabrous, punctate with dark-red glands, with nectary on abaxial surface of mid vein; stipules minute, linear, early caducous; bracteoles 2-5 mm long, entire or rarely with minute teeth at apex, caducous long before anthesis; corolla cup-shaped, the petals yellow with small dark-red spot near claw, 3-5 cm long; androecium 10-15 mm long, the filaments 3-5 mm long, pigmented red; styles 3-4 cm long, stigmatic only at tip; pollen yellow; capsules nearly spherical, 10-15 mm in diameter, 3(-4)-locular, punctate with dark-red glands, the sutures ciliate; seeds brown 7-9 mm long, with a sparse coating of appressed hairs except on conspicuous raphe.

Distribution. Isla San Marcos, Gulf of California, and near Punta



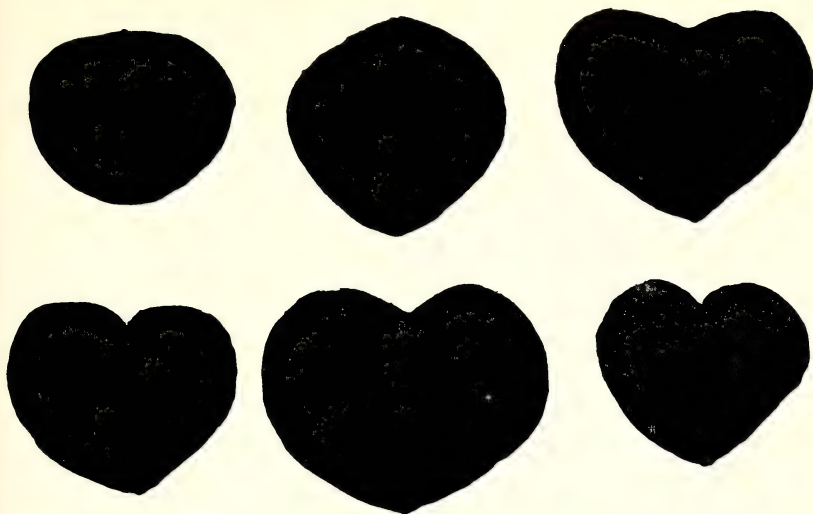


FIG. 4. Leaf-shape variation in *G. armourianum*,  $\times 1$ .

Trinidad (Lat  $27.8^{\circ}$ ) and Bahía San Francisquito (Lat  $28.4^{\circ}$ ) on mainland Baja California (fig. 1).

Major *G. armourianum* variation is summarized below:

#### *Continuous Variation*

**Plant habit.** Variants include low, decumbent, diffusely branched bushes 1 to 1.5 m tall to erect, open shrubs 2 to 3 m tall.

**Anthocyanin coloration.** Variation includes individuals that have essentially green vegetative parts to those that have a considerable accumulation of anthocyanin in stems, petioles, and leaf margins.

**Leaf characteristics.** Leaf shape in this material ranges from broadly (and rather deeply) cordate to orbicular (and non-cordate), and leaf length ranges from 1 to 4 cm (fig. 4).

#### *Discontinuous Variation*

A single plant of one accession has colorless glands rather than the normal dark-red color. The dry weight leaf gossypol assay for this exceptional plant is 0.05%, much less than the 0.65% determined for plants with typically colored glands.

*G. armourianum* and *G. harknessii* are generally similar in vegetative and floral morphology and are obviously more closely related to each other than to other species. Our study collections show each of these taxa to have considerable variability, some of which (for habit and leaf shape characteristics) blur traditionally cited distinctions between them (Kearney, 1933; Hutchnson, 1947). The two taxa do, however, have discontinuous ranges of variation for style ciliation, bracteole size, general plant pubescence, and lenticel size, shape, and number; we follow tradition in recognizing these taxa at the specific level.

## NOTES ON DISTRIBUTION AND VARIATION

The present distribution of the three Baja California wild cottons (fig. 1) indicates that the evolutionary lines that differentiated into these taxa were once sympatric over much of Baja California del Sur. As far as we can ascertain, var. *davidsonii* and *G. harknessii* are now sympatric only in a few square miles southeast of Bahía de la Paz. No evidence of hybridization involving these two taxa was observed in this area, and in fact, none was expected; it has been shown that var. *davidsonii* is cross-incompatible with most species of *Gossypium*, including all of the American diploids (Brown, 1951; Phillips, 1963).

The major distributional area of var. *davidsonii* is in the Cape region and is comprised of numerous, usually small (several to several hundred plants) populations that are often isolated from one another by considerable distances. However, we did encounter several large populations, the largest of which includes an area of 75–100 square miles at the southwest tip of the Cape region. Other rather extensive populations were found between San Bartolo and Loss Barriles and in the vicinity of Las Cruces.

Reflecting this population structure, as well as the self-compatibility and close juxtaposition of androecium and stigma in this species, the intra-population variation in var. *davidsonii* is very slight, whereas the inter-population variation is considerable. The only noteworthy intra-population heterozygosity detected by progeny testing of our var. *davidsonii* accessions was for anthocyanin coloration, and this collection was taken from the large population in the Cape region. It should be stated that individual plants and populations of var. *davidsonii* were in a very depauperate state (apparently due to browsing by cattle and goats), making field analysis of variation next to impossible. None of the variation listed above for this taxon was noted in the field. Populations of *G. harknessii*, in contrast, were unbrowsed and were amenable to field analysis of variation. The reason that *G. harknessii* is not browsed is not known, but one might speculate that an aromatic oil present in the leaves of *G. harknessii* (and *G. armourianum*), but not found in var. *davidsonii*, renders the foliage of *G. harknessii* unpalatable to livestock.

In contrast to the population structure observed for var. *davidsonii*, small, spatially isolated populations seem to be the exception rather than the rule for *G. harknessii*. Northwest of Bahía de la Paz *G. harknessii* is a co-dominant element of a vegetation type that ranges over several hundred square miles. Immediately north of Loreto and on Isla del Carmen and Isla Coronados, there are large populations of *G. harknessii*; on Isla Coronados, which is composed primarily of broken lava, *G. harknessii* is the dominant woody species.

Wide variation in vegetative and capsule characteristics (flowers were seldom seen) was evident in all populations of *G. harknessii*, though only

on Isla Coronados was variation so canalized and non-random that ecotypes could be recognized. Progeny testing of our *G. harknessii* accessions revealed a high degree of heterozygosity for each of our single-plant seed collections. Such heterozygosity doubtless is correlated with the spatial separation of androecium and stigma in the species, which though self-compatible, will not set seed in the absence of pollen vectors.

Monographers of *Gossypium* (Hutchinson, 1947; Mauer, 1954) have cited *G. armourianum* as restricted to Isla San Marcos. A *G. armourianum* collection (*J. N. Rose 16736*) taken from the peninsula ca. 100 miles north of Isla San Marcos has apparently been overlooked (the collector identified the specimen as *G. harknessii*), and recently another peninsular collection of *G. armourianum* has been made by Reid Moran, this ca. 60 miles north of Isla San Marcos.

Our study material of *G. armourianum* was limited to three single-plant seed collections from a large population of Isla San Marcos. The progeny from each of these collections included a wide array of variation for several characteristics, indicating that the individuals and populations of *G. armourianum*, like those of *G. harknessii*, contain considerable genetic heterozygosity.

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National Science Foundation, San Jose, Costa Rica

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## CALIFORNIA BOLETES III. THE GENUS SUILLUS

HARRY D. THIERS

This genus of boletes is characterized by having carpophores with a viscid pileus (rarely dry, but if so with a gelatinous hypodermis), fascicled cystidia that stain dark brown to lavender or black when mounted in potassium hydroxide, relatively small, smooth-walled spores and divergent tube trama. An annulus or veil may or may not be present. A preliminary study of the North American species of *Suillus* by Smith and Thiers (1964) indicated that the genus was well represented in California. Since that time intensive collecting has shown that the genus is among the larger, if not the largest, of the Boletaceae in the state.

Presented here are detailed descriptions of new and rare species, along with comments on distribution and other characteristics of species previously described in Smith and Thiers. All colors cited in quotes are those of Ridgway (1912), and all collections are deposited in the cryptogamic herbarium of San Francisco State College, San Francisco, California. This study was made possible by a grant from the National Science Foundation (GB 2760). It is a pleasure to express sincere appreciation for collecting permits issued by Burgess Heacox of the State Parks Department and by John O'Marie of the San Francisco Water Department.

### KEY TO SUBGENERA

- Pileus dry, or if viscid, then stipe annulate and lacking  
glandular dots on the surface . . . . . Subg. *Boletinus*  
Pileus subviscid to viscid to glutinous; if stipe is annulate, then  
glandular dots on the surface . . . . . Subg. *Suillus*

### KEY TO SPECIES OF SUBGENUS BOLETINUS

- Surface of pileus dry to moist, noticeably fibrillose to fibrillose-scaly (these characters not always apparent in very old pilei).  
Pileus reddish to reddish brown to orange-buff; fibrillose scales somewhat appressed; viscid layer below scales well developed . . 10. *S. lakei* var. *lakei*  
Pileus brick red to vinaceous tawny; scales prominent and more or less erect; viscid layer below scales often poorly developed. . . . . 11. *S. lakei* var. *pseudopictus*  
Surface of pileus viscid to glutinous or at least with viscid scales or spots; glabrous to streaked or appressed fibrillose.  
Context of pileus changing to blue then fuscous when exposed; pores 1 mm or less in width . . . . . 12. *S. lithocarpi-sequoiae*  
Context of pileus not changing to blue (but may change to some other color, and flesh of stipe may change to blue); pores usually greater than 1 mm broad.  
Annulus moist to subviscid, not glutinous, more or less fibrillose; pileus streaked to fibrillose . . . . . 6. *S. caerulescens*  
Annulus viscid to glutinous, thick, orange to yellow-orange; pileus glabrous to streaked . . . . . 15. *S. ponderosus*



## KEY TO SPECIES OF SUBGENUS SUILLUS

Flesh changing to blue when exposed . . . . . 19. *S. tomentosus*  
 Flesh unchanging when exposed or changing to some color other than blue.

Veil or false veil present, either forming as annulus or existing as a roll of tissue on the pileus margin; (check young carpophores).

Annulus typically present.

Pores up to 5 mm broad, intervenose and often lamellate; annulus evanescent; pileus yellow to dark brown.

Pileus bright yellow; stipe short, often eccentric . . . 13. *S. megaporinus*

Pileus yellowish brown; stipe well developed, not eccentric. 18. *S. riparius*

Pores not more than 2 mm broad; annulus not evanescent; pileus tan to pale brown or olivaceous . . . . . 20. *S. umbonatus*

Annulus typically absent.

Pileus when young intensely yellow, often with red fibrils; glabrous to fibrillose; pores up to 1.5 mm broad . . . . . 3. *S. americanus*

Not as above.

Pores large, often intervenose and lamellate; annulus evanescent.

Pileus bright yellow; stipe short, often eccentric . . . 13. *S. megaporinus*

Pileus yellowish brown; stipe well developed, not eccentric. 18. *S. riparius*

Not as above.

Pileus white, gray or olive when young, becoming  $\pm$  ochraceous at maturity; associated with Monterey and knobcone pines.

17. *S. pungens*

Not as above.

Pileus cinnamon brown to vinaceous cinnamon; stipe 2–4 cm. long, white when young, becoming ochraceous with age. 4. *S. borealis*

Not as above.

Glandulae prominent on stipe during all stages; associated with bishop or beach pine . . . . . 8. *S. glandulosipes*

Not as above.

Pileus yellow to "ochraceous tawny" when young, often spotted or mottled; spores  $8-10 \times 3-4 \mu$  . . . . . 21. *S. volcanalis*

Pileus white to pallid to pale vinaceous when young; spores  $6.6-8.8 \times 2.5-3 \mu$  . . . . . 2. *S. albidipes*

Veil or false veil absent or rudimentary.

Pileus conspicuously fibrillose scaly to squamulose . . . . . 7. *S. fuscotomentosus*

Not as above.

Stipe conspicuously glandular dotted.

Context white during all stages, unchanging when exposed; pores up to 2 mm broad . . . . . 16. *S. punctatipes*

Context yellow; pores typically less than 2 mm broad.

Taste unpleasant; spores  $9.3-12 \mu$  long . . . . . 1. *S. acerbus*

Taste mild; spores  $7-9 \mu$  long . . . . . 9. *S. granulatus*

Stipe not conspicuously glandular dotted.

Stipe clavate to venticose; yellow to olive buff to pale brown.

14. *S. monticolus*

Stipe  $\pm$  equal, often short; white to pallid . . . . . 5. *S. brevipes*

1. SUILLUS ACERBUS Smith & Thiers, Contr. Monogr. N. Am. Species Suillus. 103. 1964.

Originally described from collections made in the Presidio, San Francisco Co., Calif., this species has been found only in the greater San

Francisco Bay area. It apparently forms mycorrhizal associations with Monterey pine (*Pinus radiata* D. Don.) as does *Suillus pungens* Thiers & Smith with which it is frequently associated. However, *S. pungens* is distinguished by a cottony roll of veil tissue on the pileus margin and a pallid to gray color on the young pileus. *Suillus acerbus* seems most closely related to *Suillus granulatus* (Fr.) Kuntze but has larger spores and an unpleasant taste. The range of the two species apparently does not overlap since, so far as known, *S. granulatus* has not been reported from the Bay area.

2. *SUILLUS ALBIDIPES* (Peck) Singer, *Farlowia* 2:45. 1945.

As far as can be determined this species has not been reported previously from the state. Collections have been made only in the vicinity of Huntington Lake in Fresno Co. As indicated by Smith & Thiers there has been considerable confusion concerning this fungus due to the fact that Peck apparently applied this name to two distinctly different fungi—one with an annulus and one without. In our concept *S. albidipes* should be restricted to those collections lacking an annulus but possessing a roll of veil tissue on the pileus margin. In so doing this distinguishes it from *S. granulatus* with which it appears to be most closely related.

3. *SUILLUS AMERICANUS* (Peck) Snell in Slipp & Snell, *Lloydia* 7:39. 1944.

This well known species, although commonly found in the Pacific Northwest is apparently rare in California for it has been found only in the vicinity of Dinkey Creek near Huntington Lake in Fresno Co. The carpophores were typical and showed the distinctive characters associated with that species, including the yellow pileus with reddish streaks of fibrils, the distinct roll of veil tissue on the margin, the yellow pores and small stipe. They were growing in a coniferous forest composed of pines and firs.

4. *SUILLUS BOREALIS* Smith, Thiers & Miller, *Lloydia* 28:123. 1965.

The type collection of this species was made in Idaho but collections have since been made throughout the Pacific Northwest. A single collection has been found in California in the vicinity of Willow Creek in Humboldt Co. The collection was made in a mixed forest which included pines, Douglas fir and oaks. This species is best characterized by the presence of a veil, dark colored pileus, a white stipe that slowly turns yellow, and obscure glandulae on the surface. It lacks a well developed annulus.

5. *SUILLUS BREVIPES* (Peck) Kuntze, *Rev. Generum Plantarum* 3:535. 1898.

This species occurs throughout the state wherever two and three needle pines are found, and is one of the most abundant species. Most frequently it is associated with beach pine (*Pinus contorta* Doug.) in the coastal areas and lodgepole pine (*P. murrayana* Grev. & Balf.) in alpine areas. Collec-

tions have also been made, however, where only ponderosa pine (*P. ponderosa* Doug.) was present. Unfortunately its name is somewhat misleading since carpophores with stipes better than 6 cm. in length have been collected; more commonly, however, the length is 2–4 cm. It is most easily recognized by the rather dark colored pileus with a glabrous margin, and the typically short stipe that is practically devoid of glandulae.

6. *SUILLUS CAERULESCENS* Smith & Thiers, Contr. Monogr. N. Am. Species Suillus. 36. 1964.

This suillus appears to be associated with Douglas fir in California and has been found wherever this conifer grows. It characteristically fruits early in the fall and is often very abundant. It is one of the few species with a viscid pileus in which the flesh of the stipe, but not of the pileus, turns blue when exposed. This reaction is sometimes spotty and relatively slow and ample time must be allowed for the change to occur. Some difficulty might be encountered in distinguishing it from *S. ponderosus* Smith & Thiers, but the latter is usually much more brightly colored and has a heavy annulus which is glutinous and bright orange, yellow-orange or tawny in color. *S. caerulescens* occurs throughout the Pacific Northwest.

7. *SUILLUS FUSCOTOMENTOSUS* Thiers & Smith, Contr.. Monogr. N. Am. Species Suillus. 65. 1964.

This very distinctive species was described from collections made in the sand hills area near Felton, Santa Cruz Co. It was commonly found in places where ponderosa pine and several different hardwoods were growing. Since that time, however, two additional localities have been established. One of these is in the Mount Shasta area at an altitude of 5–6,000 ft., and the other in the vicinity of Twain Harte, Tuolumne Co., at 3–4000 ft. elevation. In both localities the carpophores were obviously associated with ponderosa pine.

8. *SUILLUS GLANDULOSIPES* Thiers & Smith, Contr. Monogr. N. Am. Species Suillus. 86. 1964.

This is a relatively rare species in California. With the exception of a single collection made in Patricks Point State Park north of Eureka, Calif., it has only been found in Jackson State Forest near Mendocino, Calif. Although Smith & Thiers indicated that it was probably associated with beach pine, additional observations seem to indicate that it is usually associated with bishop pine (*Pinus muricata* D. Don.), in California. Since collections have been made in such widely scattered places as Michigan, Oregon and Idaho it is obvious that it has a much wider range of mycorrhizal associates than indicated here in California. It is likely to be confused with *S. granulatus* since both species fruit simultaneously, but *S. glandulosipes* is distinguished by the distinct roll of veil tissue on the pileus margin, and paler, more vinaceous color of the pileus.

9. *SUILLUS GRANULATUS* (Fr.) Kuntze, Rev. Generum Plantarum 3:535. 1898.



This is a very cosmopolitan species, having been reported from most of the pine forested regions of the United States, and needs little additional comment. In California it has been found in the coastal forests as well as in the mountains, and is apparently associated with two and three needle pines.

10. *SUILLUS LAKEI* var. *LAKEI* (Murr.) Smith & Thiers, Contr. Monogr. N. Am. Species Suillus. 34. 1964.

This species is relatively common in the coastal forests of the state, but rare in the mountains where only one collection has been made. Like *S. caerulescens* it is associated with Douglas fir, and has been found throughout its range of distribution. Singer (1966, 1967) has indicated that this species is synonymous with *S. amabilis* (Peck) Singer, but there appears little justification for such an assumption as will be indicated by Smith and Thiers in a forthcoming paper. This is one of the few suilli with a typically dry pileus; however, care should be taken to examine young specimens since frequently in very old pilei the fibrillose scales will have disappeared and the gatinous or viscid layer will have become very pronounced.

11. *SUILLUS LAKEI* var. *PSEUDOPICTUS* Smith & Thiers, Contr. Monogr. N. Am. Species Suillus. 33. 1964.

Only one collection of this variety has been made in California. It was growing in mixed woods in Jackson State Forest near Mendocino, Calif. As indicated by Smith & Thiers it differs from the typical variety by being darker red in color and having a more pronounced scaly pileus.

12. *SUILLUS LITHOCARPI-SEQUIAE* Singer, Mycologia 51:859. 1959.

This is the only species, so far as known, that has been reported from the state that has not been seen by either Smith or Thiers. It was described by Singer from collections made in Muir Woods National Monument in Marin Co., where it is apparently very rare since year around collecting has failed to discover it. That there is some confusion regarding its relationship with other suilli and other boletes is seen in the fact that Singer has recently transferred it to the genus *Pulveroboletus* (Singer, 1962). If, however, it has the characters elaborated by him, then it should remain in *Suillus* since it has fasciculate cystidia, small pores in connection with a viscid pileus and annulus. It appears to be the only species in the section *Boletinus* in which the flesh of the pileus consistently changes to blue when exposed.

13. *SUILLUS MEGAPORINUS* Snell & Dick, Mycologia 48:302. 1956.

Pileus 2-5 cm broad at maturity; globose to convex when young, becoming broadly convex to plano-convex to highly irregular with age; surface subviscid to viscid; streaked to fibrillose to appressed fibrillose scaly, scales occasionally becoming free when very old; background colored "warm buff" to "ochraceous buff", scales colored near "cinnamon buff" to "avellaneous", sometimes becoming near "ochraceous tawny" when older; margin incurved, with obscure partial veil frag-



ments when young, glabrous at maturity. Flesh 0.5–1 cm thick, colored “warm buff” to “ochraceous buff” to near “cinnamon buff,” unchanging when exposed; taste and odor not distinctive. Tubes depressed becoming arcuate decurrent to strongly decurrent with age; up to 1 cm long; colored “antimony yellow” to “chamois,” sometimes assuming “tawny” to “russet” tints with age; unchanging when exposed; often appearing similar in arrangement to that of *Gastrobolus turbinatus*; pores up to 5 mm in length and 3 mm broad, intervenose, almost lamellate, with thick, wrinkled, irregular margins, concolorous with tubes, unchanging when bruised. Stipe 1–3 cm long, 4–7 mm broad at apex; often appearing short and reduced; sometimes somewhat eccentric; pallid to more or less concolorous with the pileus; surface becoming conspicuously glandular dotted at maturity; no annulus but obscure fibrillose annular zone sometimes apparent; flesh concolorous with that of the pileus, unchanging. Spores ellipsoid to subfusoid to subcylindric, thin-walled, hyaline in KOH, pale yellow in Melzer’s reagent,  $8.5\text{--}10.5 \times 4.5\text{--}6 \mu$ ; basidia hyaline in KOH, cylindric, 4-spored,  $25\text{--}30 \times 5\text{--}8 \mu$ ; cystidia rare on sides of tubes, abundant to crowded on pores, fascicled, no solitary cystidia seen; dark brown in KOH, chocolate brown in Melzer’s reagent, cylindric to clavate, thin-walled, heavily incrustated,  $30\text{--}48 \times 7\text{--}11 \mu$ ; tube trama hyaline, appearing subgelatinous in KOH, parallel to regular to obscurely divergent; hyphae  $3\text{--}4 \mu$  in diam., pileus trama loosely interwoven, homogenous hyaline to pale brown in KOH; cuticle differentiated as a layer of appressed to interwoven hyphae, gelatinous to subgelatinous in KOH, hyaline to pale buff to pale brown in KOH, “ochraceous tawny” in Melzer’s reagent; hypoderm compactly interwoven, dark brown in KOH and Melzer’s reagent; cuticle of stipe gelatinous in KOH, interwoven, with large clusters of caulocystidia staining dark brown in KOH, often with strong lavender tints, similar in shape and size to the cystidia on pores.

Habit, habitat and distribution. Gregarious to scattered in soil under conifers at edge of seepage areas. Carpophores usually occurring in large numbers. Known only from the general vicinity of Huntington Lake, Fresno Co., Calif., Thiers 13423, 13440.

Discussion. At the time the monograph by Smith and Thiers was published fresh material of this species had not been seen. Since that time, however, collections have been made in the type locality. This is a highly distinctive suillus. The arrangement of the tubes is such that it appears either diseased or gastroid, but a spore deposit was obtained. The pores are larger than in any other suillus and are so long radially that they have the appearance of lamellae. The stipe is very reduced, short and somewhat eccentric. Like *S. americanus* it sometimes has reddish streaks or fibrils on the surface but it does not resemble that species otherwise. In Snell and Dick’s description (1956) they noted that an ample annulus was sometimes present. This was not apparent on any of the carpophores seen although a fibrillose annular

zone could be detected on some. This species may be somewhat closely related to *S. riparius* Thiers since both species have rather large, intervenose pores, but the latter has a well developed stipe, much darker colored pileus, with a rough, scaly surface, larger cystidia and a hymeniform type of cuticle on the stipe.

14. ***Suillus monticolus*** Thiers, sp. nov. Pileus 4–7 cm latus, convexus demum plano-convexus, viscidus, appresso-fibrillosus, olivaceus vel cinnamomeus, in margine glaber, evelatus; tubuli 2–5 mm longi, straminei vel luridi; pori 1–2 mm lati; stipes 3–5 cm longus, 2–4 cm crassus, ventricosus basi bulbosus, siccus, glaber vel glandulosus, olivaceus demum cinnamomeus; sporae  $8.5\text{--}11.2 \times 3\text{--}4 \mu$ , cylindricae vel subellipsoideae; cystidia cylindrica vel subclavata,  $25\text{--}45 \times 4\text{--}9 \mu$ ; cuticula subinnexa.

Holotype. Donner Summit, Nevada Co., California, elev. 7,200 ft., Sept. 22, 1965, *Thiers 13248* (Herbarium of San Francisco State College).

Pileus 4–7 cm broad when mature; convex when young but becoming plane to plano-convex to broadly convex to highly irregular with age; surface viscid to subviscid; streaked to fibrillose to appressed fibrillose scaly; when young colored "clay color" to "pale olive buff" to "olive buff," with age changing to "buffy brown" to dark "avellaneous" to near "cinnamon brown," more or less evenly colored although the streaks or fibrils may be slightly darker; margin incurved becoming decurved with age, glabrous during all stages of development with no evidence of a partial or false veil. Flesh 0.5–1 cm thick, white, unchanging when exposed; taste and odor not distinctive. Tubes 2–5 mm long, adnate to shallowly depressed becoming decurrent to subdecurrent with age; strongly radiately arranged; when young colored "straw yellow" to "amber yellow," darkening with age to "antimony yellow" to "old gold"; pores 1–2 mm broad, often compound, concolorous with the tubes, unchanging when bruised, often staining vinaceous in KOH. Stipe 3–5 cm long, 2–4 cm broad at the apex; sometimes eccentric, distinctly ventricose to bulbous at the base and abruptly pinched below, usually bent, sometimes almost at right angles; surface dry, glabrous when young becoming glandulose to punctate to occasionally obscurely fibrillose with age; glandulae apparent only in the apical region; concolorous with the tubes at the apex usually becoming colored near "olive buff" to "cinnamon brown" toward the base; frequently reticulate at the apex; white mycelium at the base; no evidence of an annulus or partial veil; stuffed; flesh white, unchanging when exposed. Spores cylindric to subellipsoid, hyaline in KOH, pale yellow in Melzer's reagent, smooth, thin-walled,  $8.5\text{--}11.2 \times 3\text{--}4 \mu$ ; basidia clavate to subcylindric, 2- and 4-spored, hyaline in KOH,  $30\text{--}35 \times 7\text{--}10 \mu$ ; cystidia clustered, often massed, particularly abundant on the pores, scattered to numerous on the sides of the tubes, no solitary cystidia seen, staining dark brown in KOH and Melzer's reagent, usually stan-

ing more darkly on the pores, cylindric to subclavate,  $25-45 \times 4-9 \mu$ ; tube trama divergent from a distinct mediostratum, hyaline in KOH, appearing gelatinous to subgelatinous in KOH, hyphae  $3-6 \mu$  broad; pileus trama loosely interwoven, homogeneous,  $\pm$  hyaline in KOH; cuticle clearly differentiated as a trichodermum of  $\pm$  upright to somewhat tangled hyphae with free tips, walls appearing finely incrustated, subgelatinous in KOH, staining chocolate brown in KOH, ochraceous in Melzer's reagent; hypodermis compact, closely interwoven, staining brown to ochraceous in KOH, "ochraceous tawny" in Melzer's reagent; surface of stipe hymeniform, with scattered clusters of caulocystidia similar to those on the pores; no clamp connections seen.

Discussion. The most distinctive feature of this suillus is the highly bulbous to ventricose stipe that is frequently bent and often somewhat eccentric. The glandulae, while always present, are never strongly developed. The hymeniform cuticle of the stipe also appears highly distinctive. It is gregarious in soil under lodgepole pines and is known only from the type locality.

15. *SUILLUS PONDEROSUS* Smith & Thiers, Contr. Monogr. N. Am. Species Suillus. 38. 1964.

This appears to be the largest species of suillus known from the United States and pilei up to 25 cm have been collected in California. So far it has been found only in the north coastal forests under Douglas fir where it frequently fruits with *S. caerulescens*. Its most distinctive features are the typically bright yellow or orange color of the rather heavy, glutinous annulus and the bright color of the often very large pileus.

16. *SUILLUS PUNCTATIPES* (Snell & Dick) Smith & Thiers, Contr. Monogr. N. Am. Species Suillus. 94. 1964.

A single collection of this species has been made in the vicinity of Donner Pass in Nevada Co. and, as far as known, this is the first report of its occurrence within the state. It is most probably associated with lodgepole pine but the carpophores were collected in a mixed conifer forest including other species of pines and firs. The relatively large pores that are radially arranged and the white flesh of the pileus distinguish it from *S. granulatus* with which it might be confused.

17. *SUILLUS PUNGENS* Thiers & Smith, Contr. Monogr. N. Am. Species Suillus. 92. 1964.

This is the most common suillus in the San Francisco Bay area and typically fruits under Monterey pine, but collections have also been made under knobcone pine (*Pinus attenuata* Lemmon). The type collection was made on the campus of San Francisco State College where it occurs in abundance during the fall season. It is distinguished by the white roll of veil tissue on the margin, the unpleasant taste and the white to gray or olive color of the pileus when young. It has been misidentified as *S. placidus* (Bonorden) Singer because in some instances



the entire carpophore is almost pure white when young and has conspicuous drops of milky exudate on the pores. However, it soon becomes colored and does not show any additional characteristics of *S. placidus*.

18. ***Suillus riparius*** Thiers, sp. nov. Pileus 5–12 cm latus, convexus vel plano-convexus vel planus, viscidus, glaber vel fibrillosus, brunneus vel ochraceus, velo luteo, floccoso in margine; tubuli decurrentes, 1.5 cm longi, lutei vel brunneoli; pori 4 mm longi, 3 mm lati; stipes 3–8 cm longus, 0.5–1.5 cm crassus, aequalis, subviscidus, glaber, flavus; sporae cinnamomeae, subcylindricae vel subfusioideae,  $8\text{--}11.5 \times 3.2\text{--}5 \mu$ ; cystidia in fasciculis, cylindrica vel subfusioidea,  $35\text{--}75 \times 5\text{--}10 \mu$ ; cuticula innexa.

Holotype. Pinecrest, Tuolumne Co., California, elev. 5,600 ft., Sept. 28, 1965. *Thiers* 13283 (Herbarium of San Francisco State College).

Pileus 5–12 cm broad at maturity; convex to obtusely conic when young becoming plano-convex to plane to broadly convex to shallowly depressed with age, often highly irregular and undulating; surface viscid, when young smooth to glabrous to subglabrous, occasionally somewhat streaked to appressed fibrillose, typically becoming somewhat rimose to areolate to fibrillose-scaly, occasionally in very old pilei appearing somewhat squarrose scaly; when young colored "buckthorn brown" to "dresden brown" to occasionally "prouts brown," except for a cottony roll on the margin colored "antimony yellow" to "yellow ocher," scales colored "prouts brown" to "cinnamon brown" to occasionally "ochraceous tawny"; with age pileus "yellow ocher" to "old gold" to sometimes "naples yellow" to "straw yellow" to occasionally "ochraceous tawny" to "ochraceous buff" when very old; scales typically unchanging or sometimes becoming pale vinaceous when bruised; margin when young with a pronounced, large roll of veil tissue which fades to "pale olive buff" with age, either appendiculate or glabrous to eroded with age. Flesh up to 1 cm thick, soft, colored "light ochraceous buff" to "massicot yellow" to "naples yellow," changing to "avellaneous" to "drab" after exposure; taste acid, odor not distinctive. Tubes bluntly adnate when young becoming arcuate decurrent to decurrent with age; up to 1.5 cm in length; when young colored "mustard yellow" to "amber yellow," changing to "antimony yellow" to "yellow ocher" with age, sometimes becoming brownish with age, unchanging upon exposure; pores distinctly compound, somewhat intervenose, up to 4 mm in length, 3 mm in width; margin highly uneven, concolorous with tubes, unchanging when bruised. Stipe 3–8 cm long, 0.5–1.5 cm broad at the apex; more or less equal; surface moist to subviscid, glabrous except for strongly developed, elongated, irregularly shaped glandulae which are colored "sudan brown" to "amber brown"; surface colored "amber yellow" to "massicot yellow" to "mustard yellow," often darkening slightly toward the base, frequently with a slight vinaceous tint at the base; stuffed to hollow; flesh concolorous with that of the pileus, unchanging when exposed; no annulus but fibrillose zone sometimes



apparent. Spores in mass colored "cinnamon brown" to near "mars brown" to "dresden brown." Spores subcylindric to subfusoid, hyaline to pale ochraceous in KOH, pale ochraceous in Melzer's reagent, smooth, thin-walled,  $8-11.5 \times 3.2-5 \mu$ ; basidia clavate to subcylindric, 2- and 4-spored, hyaline in KOH,  $21-29 \times 8-10 \mu$ ; cystidia clustered, scattered to numerous, more abundant on the pores, staining dark brown in KOH and Melzer's reagent; sometimes discolored only in base, incrustated with incrustations floating free in mounting medium, cylindric to subclavate to subfusoid, thin-walled, occasionally hyaline in KOH,  $35-75 \times 5-10 \mu$ ; tube trama hyaline in KOH, divergent from an indistinct mediostratum, subgelatinous in KOH, hyphae  $3-5 \mu$  in diam.; pileus trama interwoven, homogeneous, hyaline in KOH; hypodermis compactly interwoven, well differentiated, brown in KOH, "ochraceous tawny" in Melzer's reagent; cuticle differentiated as a layer of interwoven to tangled hyphae partially gelatinizing in KOH; staining brown in KOH and  $\pm$  "ochraceous tawny" in Melzer's reagent, finely incrustated, hyphae  $3-4 \mu$  in diam.; cuticle of stipe hymeniform with large clusters of fascicled cystidia similar to those on the tubes, dark reddish brown in KOH; no clamp connections seen.

Habit, habitat and distributon. Gregarious to cespitose in vicinity of dead logs and stumps near edge of streams with ponderosa and sugar pines in general area. Pinecrest and Dodge Ridge Ski area, Tuolumne Co., California, Thiers 13283, 13350, 13351, 13883, 13885, 13889.

Discussion. This species occurs in large numbers along the edges of mountain streams, usually on or very near rotten stumps and logs. It is somewhat suggestive of *S. americanus* but differs in that the pileus is dark brown, and the stipe has dark brown glandulae. In addition the stipe is characteristically stouter than that reported for *S. americanus*, and the pores are yellow-brown. It might also be confused with *S. megaporinus* but the dark color of the pileus and well developed stipe make it distinct.

19. SUILLUS TOMENTOSUS (Kauff.) Singer, Snell & Dick, Mycologia 51:570. 1960.

This very abundant and easily recognized species occurs throughout the state in association with either beach or lodgepole pine. In a collection made in Nevada Co. the young pilei were densely covered with gray to olive colored fibrils which in older pilei changed to very bright red. Some fibrils commonly become disclosed, but it is unusual to find carpophores in which the fibrils are so intensely colored that the pileus is distinctly red overall.

20. SUILLUS UMBONATUS Dick & Snell, Mycologia 52:446. 1960.

As has been previously indicated in Smith & Thiers (1964) and Smith, Thiers and Miller (1965), there is some confusion surrounding this species and its relationship with *S. sibiricus* and *S. americanus*. Close comparisons between the three have been made, and it is now generally agreed that *S. umbonatus* characteristically possesses a dis-

tinct annulus, is colored pale watery brown to tan, lacks any reddish discoloration or fibrils on the pileus and shows no vinaceous discoloration in the flesh of the base of the stipe. *S. sibiricus* is characterized by lacking an annulus, having a much brighter and intensely yellow pileus and vinaceous discoloration in the flesh in the base of the stipe. *S. americanus*, although similar in color to *S. sibiricus*, characteristically has reddish streaks or fibrils on the pileus and a slender stipe.

Collections of *S. umbonatus* have been made annually in Jackson State Forest near Mendocino. The carpophores have always been found in mixed forests where both conifers and hardwoods were present, making it impossible to determine a specific mycorrhizal associate. A large collection was also made at Yuba Pass, elevation 6,700 ft., where the fruiting bodies appeared most intimately associated with alder but firs and pines were also in the vicinity.

21. ***Suillus volcanalis*** Thiers, sp. nov. Pileus 9–12 cm latus, convexus, appresso-fibrillosus, viscidus, luteus vel luridus, velo albo floccoso, conspicuo in margine; tubuli depressi, lutei, 1–1.5 cm longi; pori angulati minus quam 1 mm lati; stipes 3–6 cm longus, apice 1.5–3 cm crassus, aequalis vel ventricosus basi, solidus, non annulatus, albus, siccus, glaber, demum glandulosus, fulvus; sporae  $6.6\text{--}10 \times 3\text{--}4 \mu$ ; cylindricae vel subellipsoideae; cystidia in fasciculis, cylindrica vel subclavata,  $24\text{--}47 \times 5\text{--}8 \mu$ ; cuticula innexa.

Holotype. Butte Lake Campground, Lassen Volcanic National Park, Lassen Co., California., elev. 6,000 ft., June 27, 1965, *Thiers 12800* (Herbarium San Francisco State College).

Pileus 9–12 cm broad when mature; convex to irregular when young becoming plano-convex to highly irregular with an undulating margin to plane with an uplifted margin when older; surface often irregularly pitted; appearing closely appressed fibrillose to streaked; viscid; when young colored “primrose yellow” with numerous areas colored “ochraceous buff” to “ochraceous tawny,” when older frequently with some areas colored “picric yellow” and others “vinaceous rufous,” in some the background colored “antimony yellow” to “warm buff” with irregular areas colored “testaceous,” very old carpophores colored “russet” to “tawny” with paler yellowish areas intermixed; margin strongly incurved when young, usually with a white to pallid, conspicuous roll of partial veil tissue attached, becoming decurved and glabrous with age. Flesh 1–2 cm thick, white to “pale ivory yellow” when young typically becoming “massicot yellow” in older pilei, unchanging when exposed; taste and odor not distinctive. Tubes shallowly to deeply depressed during all stages of development; 1–1.5 cm long; when young colored “straw yellow” becoming “aniline yellow” when older; unchanging when exposed; pores angular, less than 1 mm broad, concolorous with tubes; unchanging when bruised. Stipe 3–6 cm long, 1.5–3 cm broad at apex; equal to occasionally somewhat ventricose to flared at the base; surface dry, appearing glabrous to smooth; when

very old, glandulae are apparent at least in the apex; when young white except pale yellow at the apex, when older becoming "massicot yellow" at the apex and "buckthorn brown" to "ochraceous tawny" to "tawny" toward the base; dry; no annulus; solid; flesh white when young, yellowish with age; unchanging when exposed. Spores in mass colored "sudan brown" to "sayal brown." Spores cylindric to subellipsoid, hyaline in KOH, pale yellow in Melzer's reagent, smooth, thin-walled,  $6.6-10 \times 3-4 \mu$ ; basidia hyaline in KOH, clavate, 4-spored,  $25-31 \times 7-11 \mu$ ; cystidia rare to absent along sides of tubes, scattered to relatively abundant on pores, fascicled, no solitary cystidia seen, dark brown in KOH, thin-walled, bases of many appearing incrustated, cylindric to subclavate, "ochraceous tawny" in Melzer's reagent,  $24-47 \times 5-8 \mu$ ; tube trama hyaline, divergent from a distinct mediostratum, appearing subgelatinous in KOH, hyphae  $3-5 \mu$  in diam.; pileus trama with a compactly interwoven layer near tubes which stains dark brown in KOH, surmounted by a layer of loosely interwoven, more or less homogeneous hyphae; cuticle composed of a narrow layer of closely interwoven hyphae that appear to be heavily incrustated and stain dark brown in KOH surmounting a broad layer of interwoven hyphae,  $5-6 \mu$  in diam., which appear gelatinous in KOH, dark "ochraceous tawny" in KOH; no clamp connections seen; cuticle of stipe interwoven, subgelatinous in KOH, occasional clusters of cystidia similar to those on the pores.

Habit, habitat and distribution. Gregarious to scattered (often buried) in cinders and humus under Jeffrey pines (*Pinus jeffreyi* Grev. & Balf.), Butte Lake Campground, Lassen Volcanic National Park, Lassen Co., California, elev. 6,000 ft., *Thiers 12800, 12777, 12915, 12930, 12931*.

Discussion. This species was most often found by uncovering "humps" in the soil under Jeffrey pine. Without exception it was found in dry cinder cone areas. It is somewhat remindful of *S. brevipes* but is readily distinguished by the distinct cottony margin of fibrillose tissue, the yellow to tawny color of the pileus which often appears distinctly fibrillose rather than glabrous and the much darker colored stipe. The spores are also longer and broader than those of *S. brevipes*.

#### DISCUSSION

An analysis of the state flora shows that twenty species and one variety have been collected. Seven of these are more or less cosmopolitan, having been found throughout most of the United States; six others appear to be limited to the Pacific Coast, while eight of them seem to be restricted to California. Thus more than a third of the species may be endemic, which follows the pattern of a high percentage of endemism observed in other plants within the state.

The total of twenty species equals or exceeds the number of species reported from other regions except for the Pacific Northwest (Smith and Thiers, 1964), which has a known flora of 23 species. The absence



of *Larix* in California may be a major factor in this difference in numbers. Michigan and the northeastern United States also have approximately twenty species (Smith and Thiers, 1964). The California flora is far more varied than that of the southeastern United States since only twelve species have been reported from North Carolina (Coker and Beers, 1943), nine from Texas (Thiers, 1959), and five from Florida (Singer, 1945).

As is generally known, most, if not all, species of *Suillus* are associated with conifers. If *S. lithocarp-sequoiae* is associated with *Lithocarpus* it will constitute the only known exception in the state. *Suillus caerulescens*, *S. lakei*, and *S. ponderosus* are associated with Douglas fir and all of the other species are apparently associated with pines. Along the coast beach pine and Monterey pine are most commonly involved. In the mountains, lodgepole pines are most frequently involved in mycorrhizal associations. No *suilli* have been found associated with any of the white pines, but such associates are known in other parts of the United States and probably occur here. Likewise no species have been found associated with either of the redwoods or with Sitka spruce.

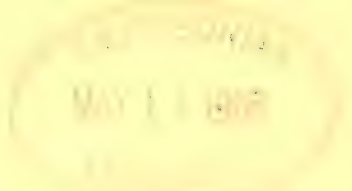
Since most of the conifers occur either along the coast or in the mountains, species of *Suillus* occupy a similar distribution. So far eight species appear to be confined to the coastal forests, six to the mountains and six occur in both areas. It is interesting to note that in both areas the fruiting period occurs in the fall with practically no carpophores appearing in the spring. In the mountains if late summer rains occur, species of *Suillus* frequently appear in abundance in late August or early September. Generally the fruiting in the coastal areas occurs within a week or two after the onset of the rainy season. Most all species fruit at approximately the same time but *lakei*, *caerulescens*, and *pungens* have a considerably longer fruiting period than the others.

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# MADROÑO

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# CHROMOSOME VARIATION IN ECOTYPES OF LARREA DIVARICATA IN THE NORTH AMERICAN DESERT

TIEN WEI YANG and CHARLES H. LOWE

A recent report has suggested the presence of a difference in chromosome number between populations of creosotebush, *Larrea divaricata* Cav., in the Chihuahuan Desert and in the Sonoran Desert (Yang, 1967). Chromosome counts from additional populations further confirm the hypothesis that  $2n = 52$  is associated with the western *Larrea* of the Sonoran Desert subdivision and  $2n = 26$  characterizes the eastern *Larrea* of the Chihuahuan Desert subdivision of the North American Desert. Chromosomes of flower buds and root tip cells were examined using aceto-carmin and aceto orcein squashes.

Table 1 gives a summary of the chromosome numbers of seven new populations recently examined, as well as the earlier reports on the chromosome counts of six other North American creosotebush populations (Covas, 1949; Powell, 1966 (pers. comm.); Yang, 1967). Figure 1 shows that all 13 populations which have provided this chromosome information are located within a distance of 100 miles either north or south of an 800-mile transect between Val Verde Co. Texas (east), and Imperial Co., California (west). This transect traverses essentially the entire longitudinal extent of the Chihuahuan Desert and the Sonoran Desert along the Mexican boundary. The transect also constitutes the only continuous east-west span of *Larrea* distribution in North America (Shreve, 1940; Garcia, Soto, and Miranda, 1960).

Nine of the populations have counts of  $n = 26$  or ca. 26 and all are located well within the boundary of the Sonoran Desert (Shreve, 1942, 1951; Benson and Darrow, 1954; Lowe, 1964). Three of the four populations with  $n = 13$  or ca. 13 occur in Trans-Pecos Texas and are within the Chihuahuan Desert proper. The remaining population with the same chromosome number ( $n = 13$ ) is located immediately west of the San Pedro Valley in southeastern Arizona, where the westernmost extension of the Chihuahuan Desert flora occurs (Benson and Darrow, 1954; Lowe, 1964). Between this Pima Co. population of Arizona and the Val Verde Co. population of Texas, covering a distance of 550 miles along the 800-mile transect, all the known chromosome counts have been in the order of  $n = 13$  or ca. 13 and  $2n =$  ca. 26. Between the easternmost Sonoran Desert population at 15 miles southeast of Tucson and the westernmost of the Imperial Co. populations of California, a span of 250 miles, all the known chromosome counts have been in the order of  $n = 26$  or ca. 26 and  $2n = 52$  or ca. 52 (Table 1).

The difference in chromosome number between the eastern creosotebush and the western creosotebush appears to be associated with the major

TABLE 1. SUMMARY OF CHROMOSOME NUMBERS OF 13 *LARREA* POPULATIONS ALONG AN 800-MILE TRANSECT IN THE SONORAN AND CHIHUAHUAN SUBDIVISIONS OF THE NORTH AMERICAN DESERT (see Fig. 1).

Population	Locality	Chromosome Count
1. California Imperial Co.	30 mi (US 80) W Colorado R.	$n = \text{ca. } 26$ $2n = \text{ca. } 52$
2. California Imperial Co.	20 mi (US 80) W Colorado R.	$n = 26$ (Yang, 1967) $2n = \text{ca. } 52$ (Yang, 1967)
3. Arizona Maricopa Co.	10.8 mi (Ariz 84) W Pinal Co. line	$n = \text{ca. } 26$ $2n = \text{ca. } 52$
4. Arizona Pinal Co.	0.1 mi (Ariz 84) W Maricopa Rd.	$n = \text{ca. } 26$ $2n = \text{ca. } 52$
5. Arizona Pima Co.	0.4 mi (Ariz 86) E Sells	$n = 26$ (Yang, 1967) $2n = \text{ca. } 52$ (Yang, 1967)
6. Arizona Pinal Co.	Boyce Thompson SW Arboretum	$2n = 52$ (Covas, 1949)
7. Arizona Pima Co.	Tucson	$n = \text{ca. } 26$ $2n = \text{ca. } 52$
8. Arizona Pima Co.	15 mi (US 80) SE Tucson	$n = \text{ca. } 26$ $2n = \text{ca. } 52$
8. Arizona Pima Co.	Saguaro Nat. Monument, Rincon Mts.	$n = \text{ca. } 26$ $2n = \text{ca. } 52$
10. Arizona Pima Co.	16.6 mi (US 80) W San Pedro R.	$n = 13$ $2n = \text{ca. } 26$
11. Texas Brewster Co.	Alpine	$n = \text{ca. } 13$ (Powell, 1966, pers. comm.)
12. Texas Brewster Co.	65.1 mi (Tex 118) S Alpine	$n = 13$ (Powell, 1966, pers. comm.; Yang, 1967) $2n = \text{ca. } 26$ (Yang, 1967)
13. Texas Val Verde Co.	1.0 mi (US 90) W Pecos R.	$n = 13$ (Yang, 1967) $2n = \text{ca. } 26$ (Yang, 1967)

ecotypic differences in morphological and physiological traits reported earlier (Yang, 1967a). The Chihuahuan Desert *Larrea*, the eastern ecotype, is distinguished by a bushy and more compact growth form, distinctly more incurved leaflets, more rapid germination rate, faster initial growth rate of the seedling, greater tolerance for low temperature, and lesser tolerance for low moisture. The Sonoran Desert *Larrea*, the western ecotype, on the other hand, has a more erect growth form, less incurved leaflets, slower germination rate, slower initial growth rate of the seedling, lesser tolerance for low temperature, and greater tolerance for low moisture.

The morphological and physiological differences between the eastern and the western *Larrea* reflect the diverse climatic regimes under which the two major populations have been evolving. The Chihuahuan ecotype is adapted to a climate of greater precipitation and relatively low winter temperature; the Sonoran ecotype had developed under a macroclimate of lower rainfall and higher winter temperature. The cytological difference in chromosome number between these two ecotypes appears to be the result of the interaction of the same genetic and ecological processes



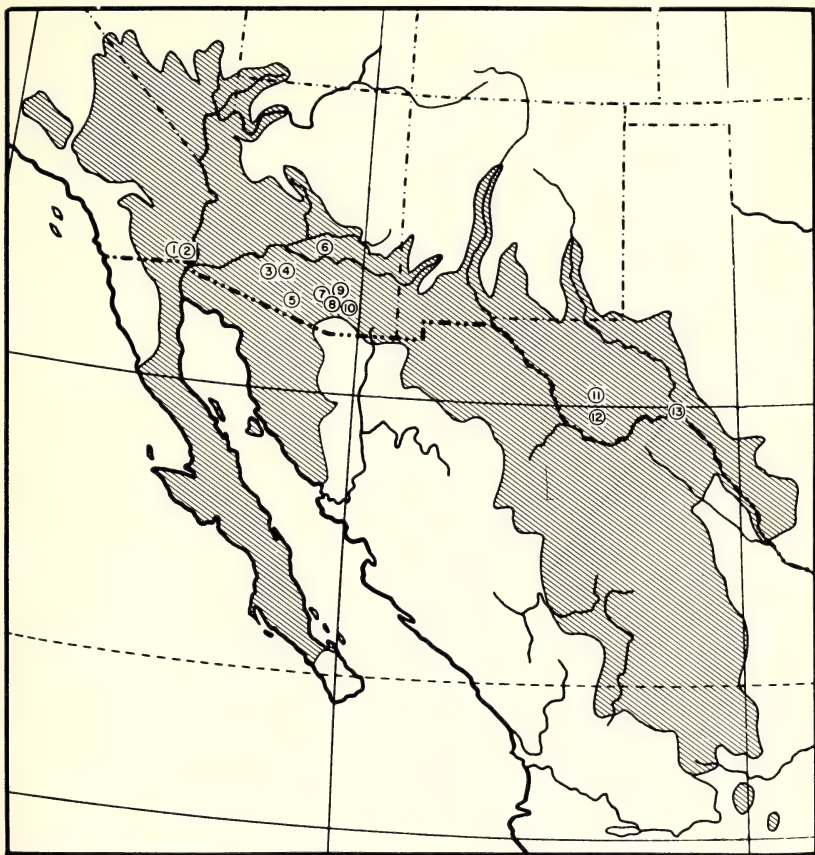


FIG. 1. Creosotebush populations studied along an 800-mile transect. Populations 1-9 are situated in the Sonoran Desert and are tetraploid. Populations 10-13 are located in the Chihuahuan Desert and are diploid (see text). Shaded area shows the generalized distribution of *Larrea divaricata* in North America, adapted from Shreve (1940), Garcia, Soto, and Miranda (1960), and modified by unpublished data from the authors.

which have brought about the series of morphological and physiological variations in the evolution of the North American creosotebush.

The authors are grateful to Walter V. Brown for suggestions, to James L. Patton for assistance in the preparation of the illustration, and to A. M. Powell for providing unpublished data. Voucher specimens are deposited at University of Texas Herbarium, University of Arizona Herbarium, and the Ecology Herbarium in the Department of Biological Sciences, The University of Arizona.

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## NOTES AND NEWS

NOTES OF THE FLORA OF ARIZONA. IV—Five collections worthy of special note have been added to the University of Arizona Herbarium. Three represent new species for the state, including one new genus, and two are range extensions.

*Urtica urens* L. represents a new weed in the Arizona flora. Our collections, made by Dr. K. C. Hamilton, came from the John Jacobs Citrus Grove on the northeast corner of the Black Canyon Highway and Peoria Avenue, in the Salt River Valley, Maricopa Co. The Dwarf or Slender Nettle is an annual from Europe which has become naturalized in the eastern United States and California.

*Chaerophyllum tainturieri* Hook. is a genus and species new for the state. Our specimen was collected by Stephen Bingham (871), eight miles north of the Safford airport, at an elevation of 4800 feet in the Gila Mountains of Graham Co. Mathias and Constance (North American Flora 28b:117-119. 1944) do not record any species of this genus west of Texas. In this work our material is determined as *C. texanum* Coult. & Rose; however, in their more recent publication on the Umbelliferae (*Flora of Texas* 3:288-290. 1951), they consider *C. texanum* a synonym of *C. tainturieri*.

*Erigeron lonchophyllus* Hook. was collected in deep grass near Aspen Spring, Lukachukai Mountains, Apache Co. (Niles & Mason 2486). This collection adds a new species to the flora of Arizona, but it is not an unexpected addition. Cronquist in his monograph of the genus (*Brittonia* 6:127-302. 1947) cites a specimen from the Tunitcha Mountains of San Juan Co., New Mexico, a mountain range which is adjacent to the Lukachukai-Chuska chain.

*Paronychia sessiliflora* Nutt. was first recorded for Arizona by McDougall (Planteau 37:107. 1965) from a specimen collected at Meteor Crater. An earlier collection by Eastwood and Howell (6918) from the same area had been misdetermined as *P. Jamesii*. More recently a third collection (Reese & Niles 850) from the East Side Game Road, Kaibab Plateau, Coconino Co. extends the range approximately 125 air miles northward and closer to the center of distribution of the species.

*Hippuris vulgaris* L., previously reported from lakes in the White Mountain area of Apache Co., has now been collected from lakes in the vicinity of Wide Lake, Lukachukai Mountains, Apache Co. (Niles & Mason 2487). This new locality is about 175 aerial miles north of the previous collection. —CHARLES T. MASON, JR., Herbarium, University of Arizona, Tucson, and WESLEY E. NILES, New York Botanical Garden.

# CYTOLOGICAL AND EVOLUTIONARY STUDIES ON PALUSTRES VIOLETS

MARJA SORSA

The genus *Viola* is well known for its many taxonomically difficult complexes. The classification is based on extensive studies carried out by different workers in Europe, North America, and Asia. However, more recent studies, specializing on smaller groups of the genus, have shown that re-evaluation of the classification is often necessary (Baker, 1949; 1953; 1957; 1960; Cain and Dansereau, 1952; Clausen, 1926; 1929; 1931; 1951; 1964; Russell, 1954; 1955; Russell and Crosswhite, 1963; Schmidt, 1961; Valentine, 1941; 1950). Within the four sections of the genus there are smaller subgroups which are in many cases connected together by hybrids only partially intersterile (Clausen, 1951). Within such subgroups a gradual chromosomal and morphological stabilization often takes place in a hybrid population, leading to introgressive establishment of several independent types, whose hybrid nature is often difficult to recognize without cytological or populational studies (Russell, 1954; Schöfer, 1954; Sorsa, 1965).

The *Palustres* group belonging to the subsection *Stolonosae* Kupffer, section *Plagiostigma* Godr. likewise presents taxonomic problems. No intensive cytological studies have hitherto been carried out on this circumpolar group of species as a whole (Clausen, 1964; Hulten, 1958).

The author had an opportunity of spending a year 1963–64 at the University of California, Berkeley, as an ASLA-Fulbright grantee. During that time herbarium material of the subsection *Stolonosae* was examined from the Herbarium of University of California, Berkeley, the Gray Herbarium, and the U.S. National Herbarium. Material for cytological studies was collected by the author on field trips from Alaska, Washington, Wyoming and California (see later for further explanation). Small flower buds were fixed in acetic-alcohol (3:1) either in the field or from plants grown first in the University of California Botanical Garden, Berkeley, and later at the Department of Genetics and the Botanical Garden of the University of Helsinki. The preparations were mostly made to catch PMC meiosis. Chasmogamous buds were preferred, because the anthers of the cleistogamous buds contain very few PMC's.

Excellent staining of squashes was obtained by the Feulgen method combined with post-staining with acetic-iron-hematoxylin adapted from Wittmann (1962).

The herbarium material of the species studied is deposited in the Botanical Museum, University of Helsinki, Finland.



## THE PALUSTRES GROUP IN EUROPE

The central species of the *Palustres* group is *Viola epipsila* Led., which is a diploid  $2n = 24$ ,  $x = 12$  being considered to be the basic number of the section (Clausen, 1927; 1929; Löve and Löve, 1961; Sorsa, 1965). It hybridizes commonly in nature with its tetraploid counterpart *Viola palustris* L., which has the chromosome number  $2n = 48$  (Clausen, 1927; 1929; 1964; Gershoy, 1932; 1934; Jørgensen et al., 1958; Löve and Löve, 1956; 1961; Schmidt, 1960; Sorsa, 1965), wherever their distribution overlaps in Fennoscandia, Northern Russia, and East Prussia (Hiitonen, 1934). It has been shown that the hybrids frequently resemble the *V. palustris* parent in morphological respects and can only be recognized as hybrids by cytological investigation or thorough analysis of a large population sample (Sorsa, 1965). The hybrid populations obviously mostly represent later hybrid generations and backcrosses with *V. palustris* (Sorsa, 1965).

*VIOLA PALUSTRIS* ssp. *JURESSII* (K. Wein.) Fourn. grows as disjunctive from *V. palustris* in France and Spain (Hulten, 1958), whereas both of the types are reported to occur in Britain (Clapham and Tutin, 1957). The taxonomic position of ssp. *juressii* has been uncertain: it has been reported as *V. epipsila* as well as a species in its own right, *V. juressii* Link. (Hulten, 1958). Its possible identity with the hybrid *V. epipsila*  $\times$  *palustris* has also been suspected (Eklund, 1958; Hiitonen, 1934). Morphologically, it is intermediate between *V. palustris* and *V. epipsila* (fig. 1). Fernandes (1950) reports the chromosome number  $2n = 48$  from NE Portugal for *V. palustris* ssp. *herminii* Wein. This type may in fact be identical with *V. palustris* ssp. *juressii*.

Cytological investigations have now been carried out on plants of *V. palustris* ssp. *juressii* grown from seed which was obtained in 1962 from Portugal, near Ponte de Lima, through the kind offices of P. Silva and J. Jalas. The chromosome number proves to be the same as in *V. palustris*,  $2n = 48$ , and the meiosis is normal, showing 24 bivalents, all of about the same size (fig. 2). As far as the chromosomes are concerned, there thus seems to be no objection to granting this taxon subspecific status as *V. palustris* ssp. *juressii*. Possibly the proper morphological species characters need reconsidering, which might result in merging ssp. *juressii* with *V. palustris*.

The *juressii* type is probably derived from the plants which were cut off in the south by the last Quaternary glaciation. It seems plausible that the tetraploid *palustris* had already spread to the new and more oceanic areas in Western Europe before the glacial period, while the diploid *epipsila* was more restricted to the continental and northern climate. The great glaciation thus left *Viola palustris* as disjunctive populations in the Central and South European mountain areas by restricting gene exchange with its more northern populations. Such a situation





FIG. 1. *Viola palustris* ssp. *juressii*, an individual grown in greenhouse from seed obtained from Portugal; morphologically an intermediate between *V. palustris* and *V. epipsila*. It is tall (10–12 cm), having bluntly acute leaves, pubescent on the underside, and bracteoles above the middle of the pedicel. The flowers are of the same size and color as in *V. palustris*, only the spur being longer. In cultivation ssp. *juressii* is vigorous, spreading cleistogamously by seed and vegetatively by stolons.

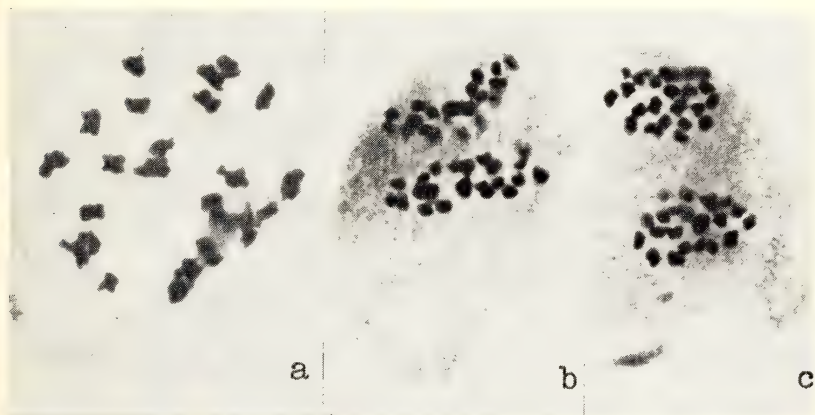


FIG. 2. PMC-meiosis in *V. palustris* ssp. *juressii*: a, Diakinesis showing 24 bivalents all about the same size; b, Anaphase I showing regular separation of paired chromosomes; c, Metaphase II showing  $n = 24$  in both plates,  $\times$  ca. 1200.

would explain the slightly different morphological evolution of the southern isolates through genetic drift.

#### THE PALUSTRES GROUP IN NORTH AMERICA

*Viola palustris* has been used as a kind of general expression for Palustres violets in North America by many American taxonomists. Apart from wrong annotations on the herbarium specimens, *V. palustris*



FIG. 3. A plant of *Viola epipsila* ssp. *repens* from Moose Creek, Alaska; glabrous, acute leaves, larger flowers and smaller plant size (8–10 cm) than in *V. epipsila*.

is often confused with *V. epipsila* ssp. *repens*, *V. macloskeyi* ( $n = 12$ ), *V. pallens* ( $n = 12$ ), *V. renifolia* ( $n = 12$ ), *V. incognita* ( $n = 22$ ), or even *V. blanda* ( $n = 22$ ), the North American *V. palustris* is by no means a uniform taxonomic entity.

Cytological investigations have now been carried out on four types belonging to the North American *palustris* complex as well as on one closely related member of the group.

*VIOLA EPIPSILA* Ledebour ssp. *REPENS* (Turczaninov) Becker, Bot. Centralbl. Beiheft 34(2): 406. 1917, has a wide distribution, from Eastern Asia to Alaska and western Canada. (Anderson, 1959; Hulten, 1947; 1958). It is reported from British Columbia and Washington (Hitchcock et al., 1961; Hämet-Ahti, 1965) but the specimens seen from that area differ slightly from the Alaskan type in morphological features. Moreover, the chromosomal condition seems to be quite different (see later for *V. palustris* in Washington).

Morphologically, the subspecies *repens* differs from the main type *V. epipsila* by a smaller size, glabrous but distinctly acute leaves, and larger flowers (fig. 3).

The chromosome number of the western subspecies has not been reported from North America (Clausen, 1964). However, in 1930 Miyaji determined the chromosome number  $n = 12$  of a plant listed as *V. repens* Turcz. from the moors of Hokkaido. Obviously, this is the Japanese form of *V. epipsila* ssp. *repens*. The same chromosome number was now determined on specimens of three populations collected in Central Alaska, at Kantishna, Camp Denali and Moose Creek. The meiotic division is regular (fig. 4). No differences could be detected in chromo-

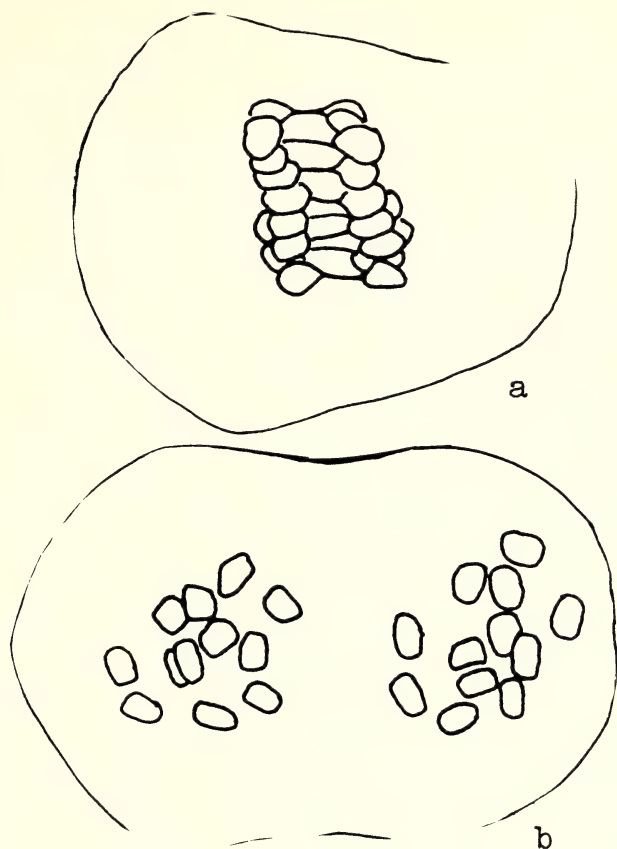


FIG. 4. PMC-meiosis of *V. epipsila* ssp. *repens* from Moose Creek, Alaska: a, Anaphase I showing regular separation of bivalent halves; b, Metaphase II showing  $n = 12$  in both metaphase plates,  $\times$  ca. 1800.

some size or morphology between the Fennoscandian *V. epipsila* and the Alaskan ssp. *repens* (see Sorsa, 1965). The mitotic division accordingly showed  $2n = 24$ .

*VIOLA ACHYROPHORA* Greene, Pittonia 5: 33. 1902, has been reported from both continents in the Beringean area (Hulten, 1947; 1958), though not listed in the Flora of USSR (15:402-404. 1949). Hulten (1947) and Anderson (1959) were hesitant to rank this type as a separate species, merely because of slight morphological differences and a more northerly distribution. In the author's opinion, as well, the differences (smaller size, rounder and thicker leaves) between "*V. achyrophora*" and *V. epipsila* ssp. *repens* are mainly due to modification in the poorer and more northern habitats. No differences between the two are observable in style shape, either.

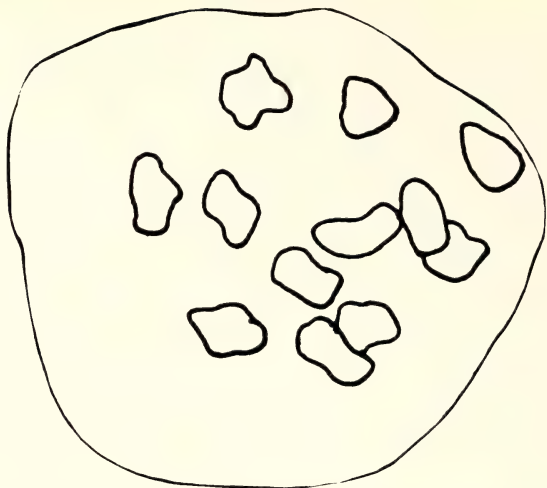


FIG. 5. PMC metaphase I of "*V. achyrophora*" from Chatanika River, Alaska, showing 12 normal bivalents all about the same size,  $\times$  ca. 1800.

The chromosomal picture of the *V. achyrophora* type is regular, showing 12 bivalents in meiosis, and no differences from *V. epipsila* ssp. *repens* can be noticed on the chromosome level (fig. 5). The same chromosome number has been found in both populations sampled north of Fairbanks, Alaska, namely Chatanika and Miller House.

It would seem more logical to regard "*V. achyrophora*" as just a northern variant of *V. epipsila* ssp. *repens* keeping it under the same specific name.

*VIOLA PALUSTRIS* Linnaeus, Sp. Pl. 934. 1753. As mentioned earlier, the name *V. palustris* has quite often been used as a general denomination for the whole *palustris* complex in North America. The author's acquaintance with the *palustris* type in the Eastern United States and Canada is restricted to herbarium material collected mostly around the turn of the century. Morphologically, this material is very near to the North European *V. palustris*, which is known also from Iceland, from where the chromosome number  $2n = 48$  has been reported by Löve and Löve (1956), and Southern Greenland, from where  $2n = 48$  has been confirmed by Jørgensen et al. (1958). In eastern North America the species occurs in New Foundland, Gaspé Peninsula, and Quebec on the Canadian side. From eastern U.S. it is reported around the White Mountain area only (Russell, 1965). However, no chromosome counts are available.

The *palustris* material seen from western North America, from British Columbia, Washington and the adjacent areas is morphologically quite near to what in Europe is considered the *epipsila* type (Hulten, 1958) in size, shape of leaves, flower characters and ecological requirements (fig. 6).





FIG. 6. Plants of the collective species of *Viola palustris* from Mt. Rainier Nat. Park, Washington. Morphologically this plant appears nearer the *epipsila* type: the flowers are large, pale blue, and have a long spur. Bracteoles are above the middle of the pedicel. Only two leaves are present at the time of flowering (*V. palustris* having three or more). Only the shape and glabrousness of the leaves resemble the *palustris* type.

Gershoy (1934) reported the chromosome number of  $2n = 48$  from the Pacific coastal form of *V. palustris*, collected in the vicinity of Ocean Park, British Columbia. This plant was cytologically regular, having 24 bivalents in metaphase I. According to the morphological description of the plant given by Bold and Gershoy (1934) there are slight differences with the North European *palustris* e.g. in shape of leaves and color of seeds.

The herbarium specimens labelled as *V. palustris* from the Pacific coastal areas show a confusing variation of types not typical at all if compared with the North European *V. palustris*. Unfortunately no material was obtained of the Pacific coastal types in spite of several field trips to the sites of growth in California, given on the herbarium sheets (Humboldt Co., Mendocino Co.).

The writer has studied cytologically two types of the western *palustris* complex from Washington and Wyoming.

Plants belonging to the *Viola palustris* complex were fixed from an abundant population in Frog Heaven, Mt. Rainier National Park, Washington. Though the plants were morphologically more of the European *epipsila* type (fig. 6), they chromosomally belonged to the tetraploid level. The meiotic metaphase I showed minor irregularities in the first division (fig. 7). The meiotic picture very much resembles that of the previously studied *V. palustris*  $\times$  *epipsila* hybrids in Finland (Sorsa,

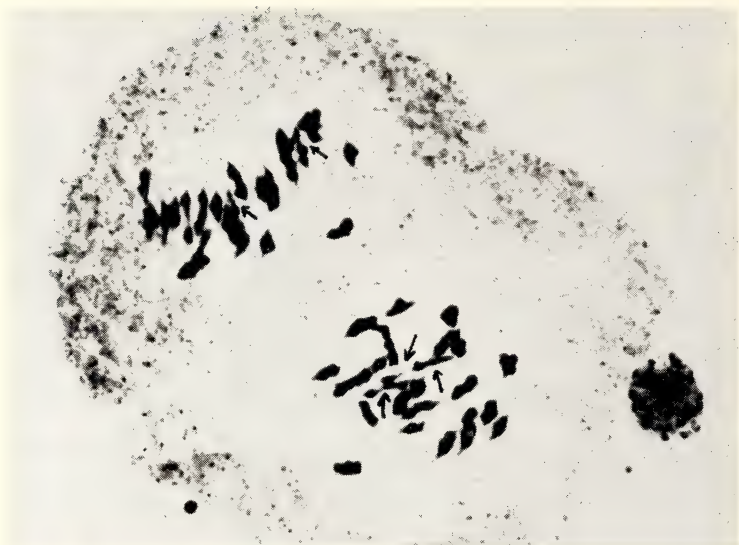


FIG. 7. Two PMC's in metaphase I of the *V. palustris* plant from Mt. Rainier Nat. Park, Washington. The orientation of the chromosomes is slightly irregular three small univalents (arrows) dividing not completely synchronous with the bivalent separation.  $2n = 22-23_{II} + 2-3_{I}$ ,  $\times$  ca. 1200.

1965). Both seem to be well stabilized hybrid derivatives with little hybrid unbalance, the somatic chromosome number maintaining around  $2n = 48$ . The occurrence of the *epipsila* type characters in the tetraploid level such as the position of bracteoles and the number of leaves suggests the emerging of the *epipsila* genome. This can either be due to actual hybridization of the *palustris* type with the diploid *V. epipsila repens* taken place relatively recently. One can also think of the *epipsila* type as one of the progenitors of *palustris*, which would then lead into the emergence of various combinations of parental characters in different environments. It seems to me highly probable that some of the obscure western *palustris* types are of hybrid origin. The possible partners in the hybridization that obviously took place quite long ago will be discussed later.

*VIOLA PALUSTRIS* ssp. *BREVIPES* Baker, Madroño 6: 235. 1936, has been described from several sites along the Colorado River at altitudes of 7500-10000 ft (Baker, 1936; probably also Russell, 1963). This white-flowered violet has obviously quite frequently been confused with *V. pallens* and *V. blanda*. The plant was found in July 1964 near Lewis Lake, Yellowstone National Park, Wyoming, though stated to be *V. blanda* in the local flora (McDougall and Baggle, 1956). All characters, e.g. shape of style, beardless petals, size, shape of leaves and flowers (fig. 8) fit the description of Baker (1936) for ssp. *brevipes*.



FIG. 8. A plant of *Viola palustris* ssp. *brevipes* from Yellowstone Nat. Park, Wyoming. It has white flowers, a short spur, beardless petals, and has bracteoles above the middle of the pedicel. It is small, 5–8 cm, and the leaves are orbicular-cordate with regularly crenate margins.

The meiotic picture is suggestive of some hybridity in the population, revealed by somewhat irregular pairing and the presence of 2–5 univalents (fig. 9). Clausen (1964) also reports *V. palustris* ssp. *brevipes*, a type specimen from Colorado, Estes Park, as a hybrid derivative having "36–38 pairs or singles." If about 12 are singles, the chromosome number might have arisen as a result of hybridization of a tetraploid and a diploid counterpart. Clausen's plant from Baker's type collection possibly represents a young hybrid generation, in which chromosomal stabilization has not yet taken place. The Yellowstone population, in turn, may represent an older, balanced hybrid derivative, showing a rise of chromosome number and moderate stabilization, which is by no means uncommon among the violet hybrids (Brainerd, 1921; 1924; Clausen, 1922; 1926; 1931; Schmidt, 1961; Sorsa, 1965).

Without thorough experimental evidence one can only hazard a guess at the most probable history of this hybrid derivative. On morphological grounds (white flowers, round leaves, small size) the likeliest possibility would appear to be hybridization of the tetraploid western *palustris* type with the diploid *V. macloskeyi*, which occurs in similar habitats and areas. This continental and montane to subalpine form is possibly still evolving.

The chromosome number of *VIOLA MACLOSKEYI* Lloyd, *Erythea* 3: 74. 1895, was verified as  $n = 12$  from specimens collected from four



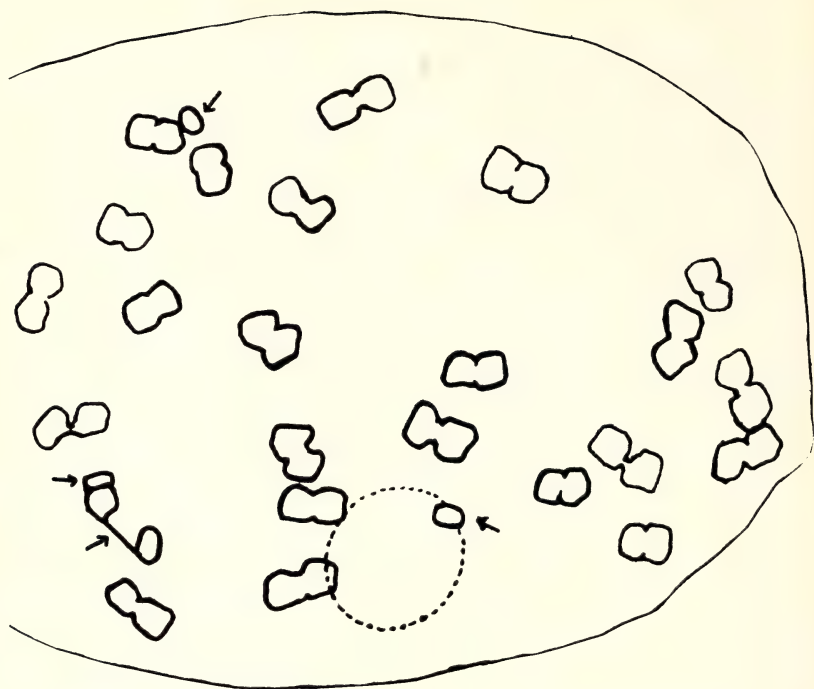


FIG. 9. Diakinesis of PMC meiosis in *V. palustris* ssp. *brevipes* from Yellowstone Nat. Park, Wyoming; irregular pairing of the chromosomes, 24 bivalents (one loosely paired) and 3 fragments can be seen,  $\times$  ca. 1800.

populations, three from Yosemite National Park, California and one from a transplant No. 62.1302 in the Botanical Garden at Berkeley originally collected from Lake Tahoe (fig. 10). The same chromosome number has been reported earlier (Baker, 1953; Clausen, 1964).

#### REGIONAL AREAS OF SPECIES

The phylogenetic outlines of the genus *Viola* have been discussed most thoroughly by Clausen (1929). Although deductions of this type are always somewhat speculative, a combination of cytological, genetical and geographical information can provide some clue to what happened in the past. The *Palustres* group probably originated in north-eastern Asia, similarly to many circumpolar groups of species. The diploid level is represented as *Viola epipsila*, and the tetraploid as *V. palustris*. The ready hybridization of the two suggests that the origin of the tetraploid *palustris* was probably through hybridization of two diploid types, one of which was the *epipsila* type (fig. 11).

The tetraploid type has expanded its range into more oceanic environments, while the diploid *epipsila* type covers the more continental areas of Northern Europe, and as a slightly differentiated subspecies



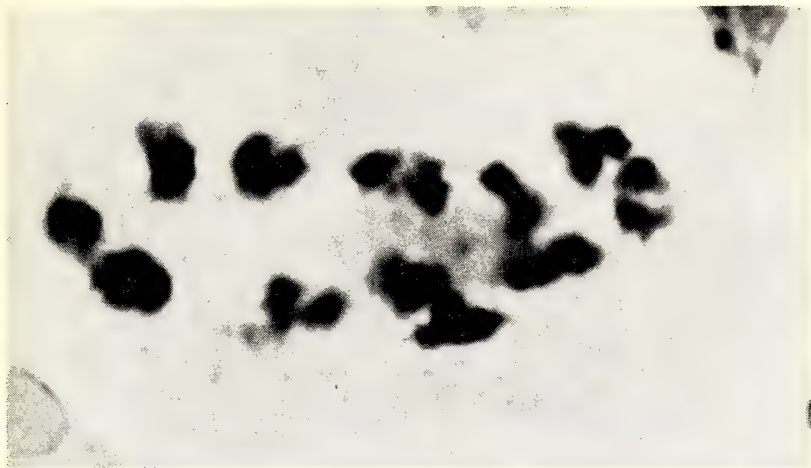


FIG. 10. Diakinesis of PMC meiosis in *Viola macloskeyi* grown in Botanical Garden, Berkeley (No. 62.1302);  $n = 12$ , the bivalents appear to be mostly ring-shaped, which was found to be frequent in all the *macloskeyi* samples studied,  $\times$  ca. 1200.

*repens* extends to Siberia and the Beringean area as far as Alaska and possibly western Canada. The tetraploid *palustris* type is widespread in Europe and is connected to Eastern North America over Faeroe Islands, Iceland and Greenland. In North America it tends to have a bi-coastal distribution, although the author is inclined to believe that the original "Linnean" species *V. palustris* is confined to the eastern coast, i.e. Newfoundland and Gaspé Peninsula in northeastern Canada, and the White Mountains area in the United States, while the western types of *palustris* are less typical and often show variation in character combinations.

It seems probable that much of the variation of the *palustris* type is caused by hybridization with ecologically and karyologically suitable related violets, such as species of the diploid group ( $n = 12$ ) *V. macloskeyi*, *V. pallens* and possibly also *V. lanceolata*, *V. primulifolia* and *V. renifolia*. Evidence from the extensive crossing experiments of Gershoy and his co-workers (Bold and Gershoy, 1934; Gershoy, 1934) drops out the more distant relatives of the Palustres group such as *V. blanda* and *V. incognita* (both  $n = 22$ ) and *V. selkirkii* ( $n = 12$ ). The possibility of hybridization between the eastern *palustris* with the northwestern *epipsila repens* cannot be excluded, either.

The cluster of species forming the Palustres group thus seems to consist of one tetraploid, *V. palustris*, and at least three diploids, namely *V. epipsila* and the species pair *V. macloskeyi*-*V. pallens*. Experimental evidence is needed to confirm their evolutionary possibilities in creating the variety of forms that constitute the taxonomically difficult Palustres group.

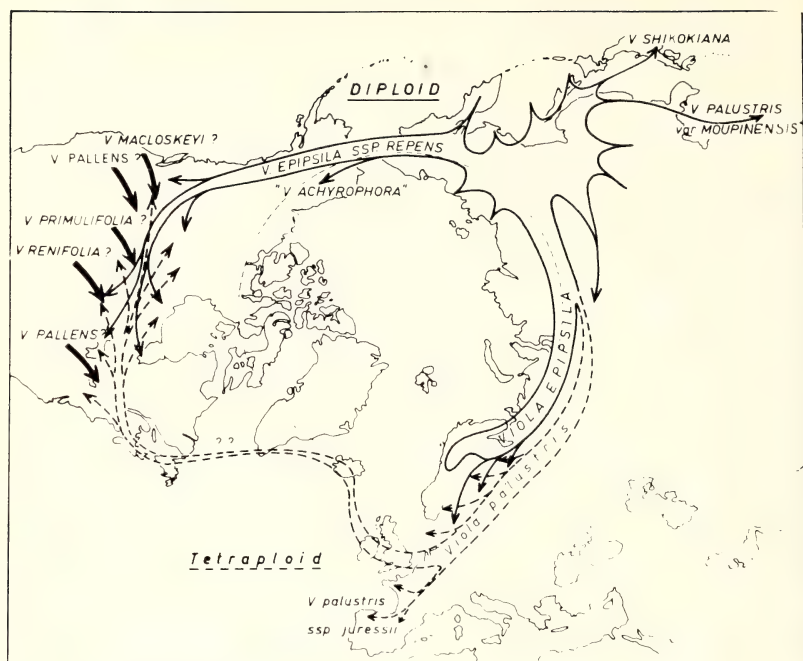


FIG. 11. Schematic representation of the speculative evolutionary outlines in the *Palustres* group. The full lines represent diploid species, the broken lines tetraploid species. Heavy arrows in North America suggest the possible contributors to the variability of the *palustris* complex. *V. shikokiana* ( $n=12$ , Miyaji, 1929) is the East Asiatic counterpart of the *macloskeyi-pallens* species pair, *V. palustris* var. *moupinensis* is probably a separate species reported from Southern China. See further in the text.

#### ACKNOWLEDGMENTS

I wish to express my sincere gratitude to the great authority on the genus *Viola*, Jens Clausen, Carnegie Institution of Washington, Stanford, for reading the manuscript and making numerous valuable comments both to amend the factual information and to improve my English text. I also want to thank Esko Suomalainen, University of Helsinki, Finland, for advice and encouragement during the studies, and Jaakko Jalas, University of Helsinki for help and criticism during the work. Herbert G. Baker, Margaret Bergseng and Annetta Carter, University of California, Berkeley, were always kindly helping me in many ways during my stay at Berkeley.

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## SUMMARY

Chromosome numbers of violets belonging to the Palustres group, subsection *Stolonosae* Kupff. are reported:

*Viola palustris* ssp. *juressii* (K. Wein.) Fourn.  $n = 24$ , from cultivated plants grown from seed obtained from Portugal, near Ponte de Lima. Meiosis normal.

*Viola epipsila* ssp. *repens* (Turcz.) Becker,  $n = 12$ , from three different localities in Central Alaska (Kantishna, Camp Denali, Moose Creek). Meiosis normal.

"*Viola achyrophora*" Greene,  $n = 12$ , from two localities in Northern Alaska (Chatanika, Miller House). Meiosis normal. It is suggested that this type should be treated rather as belonging to *V. epipsila* ssp. *repens*.

*Viola palustris* (coll.),  $n = 22-23_{II} + 2-3_{I}$ , slightly irregular meiosis, from Frog Heaven, Mt. Rainier National Park, Washington. The type obviously represents a stabilized hybrid derivative probably quite frequent among the North American *palustris* complex.

*Viola palustris* ssp. *brevipes* Baker,  $n = 22-24_{II} + 3-5_{I}$ , slightly irregular meiosis, from Lewis Lake, Yellowstone National Park, Wyoming, represents a type of stabilized hybrid derivative. The most probable progenitors are the western *palustris* type and the white-flowered diploid *V. macloskeyi*.

*Viola macloskeyi* Lloyd (= *V. macloskeyi* ssp. *macloskeyi* Baker),  $n = 12$ , normal meiosis, from a Lake Tahoe transplant and three sites in Yosemite National Park, Calif.

The emergence of some key morphological characters of *V. epipsila* on the tetraploid level in *V. palustris* ssp. *juressii* and especially in the western North American *V. palustris* has been observed and discussed.

The distribution of the diploid and the tetraploid types of the Palustres group has been presented. The group seems to consist of an evolutionary active complex, able to balance itself in different environments by forming various types due to selection and genetic drift.

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## A SECOND SPECIES OF AMMOBROMA (LENNOACEAE), IN SINALOA, MEXICO

ROBERT L. DRESSLER AND JOB KUIJT

The genus *Ammobroma* has stood as a monotypic taxon since its initial description more than a hundred years ago (Gray, 1854). Its single species, *A. sonorae*, has through the years attracted much casual attention because of the curious, mushroom-like appearance of the plant, and because of its early use as an edible plant by some of the indigenous Indian tribes of the Sonoran region. It is of some interest to note that Dr. Jerry Rzedowski has observed the use of *Lennoa* also as a vegetable in the State of San Luis Potosí (personal communication). Notwithstanding the obvious interest in these bizarre parasites very little botanical work has been done in the family.

It is not our intention here to enter into a discussion of the generic distinctions between the three known genera of Lennoaceae (*Ammobroma*, *Pholisma*, and *Lennoa*). Even a casual acquaintance with *Pholisma* and *Lennoa* leaves one with an uneasy feeling about their validity as genera. It could even be argued that the main generic feature of *Ammobroma*, i.e., the compact, laterally extended head, is insufficient by itself as a generic distinction.

Whatever generic delimitations may be used in the future, it is of great interest that we can now add a new species to this small family. At present the species must undoubtedly be placed in *Ammobroma*. The plant was first observed by the senior author in December, 1949, in the region of Culiacán, Sinaloa. Only dried and decomposed remains were found at that time. It could be ascertained, nevertheless, that the plants were attached to the roots of *Euphorbia* (*Agaloma*) *californica*. More recently (August, 1957), a second visit was made to the same locality, and many flowering plants were found on the roots of *Euphorbia californica*, *Jatropha curcas*, and *J. cordata*. As now known, the parasite is

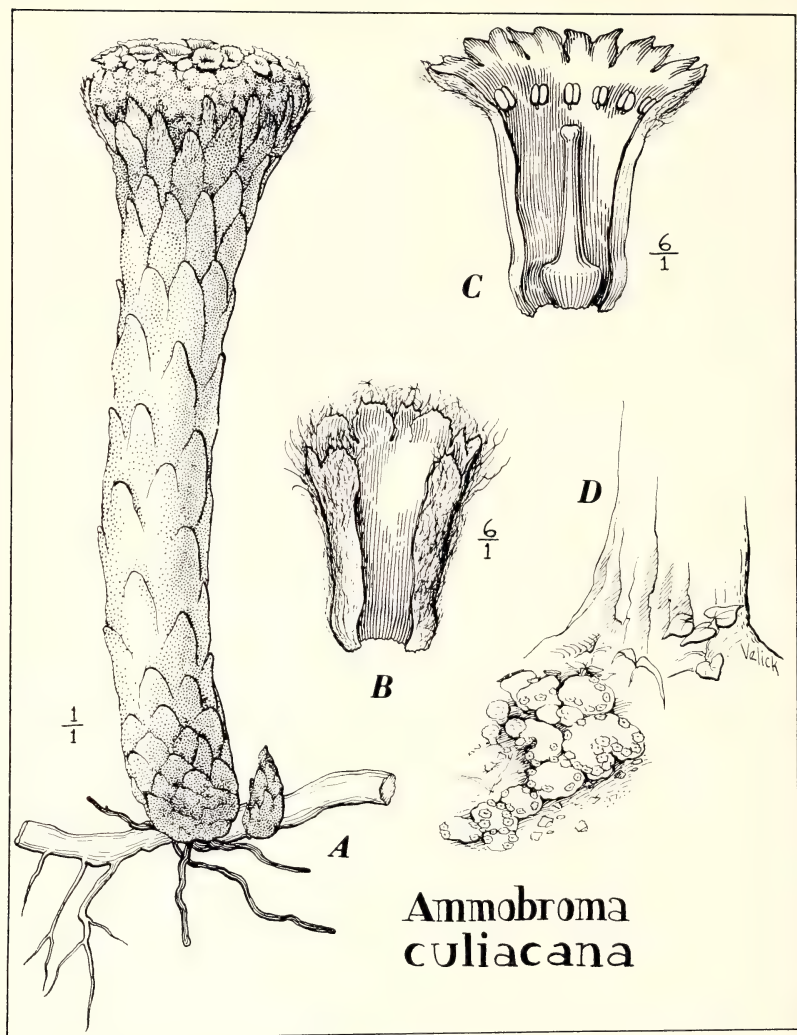


FIG. 1. *Ammobroma culiacana*: a, complete plant on root of host plant, showing you shoot and the roots of the parasite; b, calyx, split open; c, corolla, split open to show pistil and anthers; d, a clump of plants as seen in nature (from a kodachrome).

quite local, having been found only on a rocky ridge about 15 km south of Culiacán, from which we derive the specific epithet.

*Ammobroma culiacana* Dressler & Kuijt, n. sp. Caules carnosí, 8–10 cm longi, 1.5–2.0 cm crassí, orientes e radice nutritia ipsa vel paene; folia squamiformia, parva, basalia deltoideo-ovata glabraque, media longiora, superiora circa basim inflorescentiae involucrum efformantia. Inflorescentia capitulum compactum, 3–10 cm diam., hemi-

sphaericum, suborbiculare sed demum circumscriptione irregulari. Flores sessiles vel breviter pedicellati; calyx tubulosus, extra dense pilosus, praecipue superne, 5–5.5 mm longus, incisus ad 1.5–2.5 mm, lobis 6–8, obtusis, irregulariter dentatis, 1–2 mm latis. Tubus corollae 6–6.5 mm longus, glaber; lobi corollae 6–8, patentes, bifidi, plicati, 2.5–3 mm longi, 1.5–2 mm lati, intra glabri, extra sparse pilosi; stamina isomera, lobis corollae alternantia. Filamenta 0.3 mm longa, antherae ca. 0.7 mm longae; ovarium turbinatum, ca. 1.8 mm latum. Stylus ca. 4 mm longus, stigma integrum, capitatum. Fructus semiglobosus, 3–3.5 mm diam.; nuculae 14–18, reniformi-ovoideae, applanatae, ca. 1 mm longae; testa cellulis magnis, papillois.

Stems fleshy, 8–10 cm long, 1.5–2.0 cm in diameter, arising directly from the infected host root or nearly so; leaf scales small, the basal ones deltoid-ovate and glabrous, the middle ones longer, the upper ones forming an envelope of densely pilose, linguiform to ovate, imbricating scales around the base of the florescence. Inflorescence a compound head 3–10 cm in diameter, hemispheric, more or less circular, but becoming irregular in outline. Flowers sessile or shortly pedicellate, calyx tubular, densely pilose without, especially on upper parts, 5–5.5 mm long, divided for 1.5–2.5 mm into 6–8 obtuse, irregularly dentate lobes 1–2 mm in width; corolla tube 6–6.5 mm long, glabrous; corolla lobes 6–8, spreading, bifid and plicate, 2.5–3 mm long, 1.5–2 mm wide, glabrous within, somewhat pilose without, stamens as many as corolla lobes and alternating with them. Filaments 0.3 mm long, anthers ca. 0.7 mm long, ovary turbinate, ca. 1.8 mm wide; style ca. 4 mm long, stigma entire, capitate. Fruit subhemispheric, 3–3.5 mm in diameter, nutlets 14–18, reniform-ovoid, flattened, about 1 mm long, seed coat consisting of large, papillose cells.

Specimens examined. Mexico. Sinaloa: about 15 km south of Culiacán (km 1410), rocky soil in thorn forest, parasitic on roots of *Euphorbia californica*, *Jatropha curcas* and *J. cordata*, indument and exposed bracts pink, flowers cream with pink shading, Dressler 2175 (F, GH, K, MEXU, MO, NY, UBC, UC-holotype, US, VEN), Aug. 11, 1957; 10 miles south of Culiacán, rocky thorn forest, parasitic on roots of *Euphorbia*, Dressler 984 (MEXU, MO, UC, US), Dec. 22, 1949.

*Ammobroma culiacana* differs from all other known Lennoaceae in its gamosepalous clyx. The remaining members of the family, including *A. sonorae*, have very narrow sepals which are free to the base or nearly so. The matted indument of the sepals gives the heads a flesh-pink color in life. The corollas are cream or tinged with pink and, unlike those of other Lennoaceae, do not contrast markedly with the pale indument of the head. A faint, sweet odor was detected, and the flowers were visited by flies, beetles, and small butterflies. As the inflorescence matures and expands laterally the (earliest) flowers in the central portion become dark brown. The entire perianth persists even when the fruit is mature. The latter, in agreement with other Lennoaceae, is a capsule-like fruit which appears to open by means of an irregular, circumscissile rupture.

It seems that mechanical destruction of old inflorescences is necessary before the seeds are set free.

The inflorescence of *Ammobroma culiacana* may be said to be somewhat intermediate between those of *A. sonorae* and the *Pholisma-Lennoa* complex. In the latter two genera we find a panicle-like inflorescence in which the balance between lateral and terminal expansion has been variously struck. *Lennoa* and *Pholisma depressum* (*P. paniculatum* Templeton) show a great deal of lateral branching (Suessenguth, 1927; Templeton, 1962), but in *P. arenarium* the inflorescence approaches a short, dense spike. In *Ammobroma culiacana* a further contraction has taken place, and we can speak of a determinate, disk-like inflorescence axis and an involucre of bracts. The extreme is reached in *A. sonorae* with a very dense capitulum the margin of which unrolls well above the upper leaves. Reduction of floral bracts seems to run parallel to this series: in *Pholisma* and *Lennoa* each flower has a subtending bract but such organs are no longer recognizable in *Ammobroma*, at least not in the central area of the disk.

Although details of root morphology cannot be ascertained at this time, one interesting feature is clearly shown in the collections cited, and is illustrated in Fig. 1A. The stem originates directly from the host root, or nearly so. On the basis of what is known for *Pholisma* (Kuijt, 1968) and the collections cited, we can tentatively reconstruct the following course of events in *Ammobroma culiacana*. Long roots traverse the soil. When the host rhizosphere is invaded, small haustorial roots are formed nearest the host root and grow towards the latter, finally invading it. A dark, irregular, tubercular mass of variable size develops in the haustorial region. It is from this callus-like cushion that the stem is developed. This is in direct contrast to the situation in *Pholisma*, where stems arise from the roots of the parasite between successive haustorial attachments, but not at the point of host contact. The parasitism of *A. culiacana* would seem to represent an evolutionary advance over that of *Pholisma* in that it involves a more immediate dependence of the inflorescence on the roots of the host.

We wish to express our indebtedness to Dr. Karel U. Kramer for the Latin diagnosis.

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## CHROMOSOME NUMBERS IN THE TRIBE PAPPOPHOREAE (GRAMINEAE)

JOHN R. REEDER AND D. N. SINGH

In a recent paper, Reeder (1965) pointed out that on the basis of anatomical characters of the leaf and embryo, the tribe Pappophoreae can be divided into two rather distinctive subgroups. One of these, which includes only the genus *Pappophorum*, was designated subtribe Pappophorinae. The other, comprising the genera *Cottea*, *Enneapogon*, *Kaokochloa*, and *Schmidtia*, was named subtribe Cottinae. In the paper referred to above, the cytology of members of the tribe Pappophoreae was not discussed.

Cytological information on members of this tribe published to date suggests that basic chromosome numbers of both  $x = 9$  and  $x = 10$  occur. Apparently the only species of *Pappophorum* which have been examined cytologically are *P. bicolor* Fourn. and *P. mucronulatum* Nees. For both of these, Brown (1950) and Gould (1958; 1966) have indicated that the chromosomes are in multiples of ten. The lowest number reported in either species is  $2n = 40$ .

The only published record for the monotypic genus *Cottea* is that of Covas (1945). He examined Argentinian material of *C. pappophoroides* Kunth, and reported  $2n = 20$ .

One Indian, four African, and one American species of *Enneapogon* have been subjected to cytological study. Covas (1945) reported  $2n = 20$  in Argentinian material of *E. desvauxii* Beauv. (as *Pappophorum wrightii* S. Wats.). This number has been confirmed by Gould (1960, 1966) and Reeder (1967) in collections from Mexico and the United States. A diploid number of  $2n = 20$  was also determined for *E. elegans* (Nees) Stapf by Janaki-Ammal (in Darlington & Wylie, 1956). For *E. scoparius* Stapf, de Wet (1954) listed  $2n = 36$ . Although basic numbers of  $x = 9$  and  $x = 10$  are common in grasses related to *Enneapogon*, curiously de Wet concluded that in this genus the basic number is  $x = 12$ . This would imply, of course, that his plant was triploid. In a later paper, de Wet & Anderson (1956) record the same number ( $2n = 36$ ) for *E. scoparius*, and also for *E. cenchroides* (Licht.) C. E. Hubbard, and *E. brachystachys* (Jaub. & Spach) Stapf. For *E. pretoriensis* Stent, they report a chromosome number of  $2n = 18$ . On the basis of this latter count, the authors suggest that the basic number in *Enneapogon* is probably  $x = 9$ . Thomas (in Darlington & Wylie, 1956) also gives  $2n = 36$  as the chromosome number for *E. cenchroides*.

The two published chromosome counts for the genus *Schmidtia* are by de Wet & Anderson (1956) and de Wet (1958). These authors report  $2n = 36$  in *S. glabra* Pilger, and also in *S. bulbosa* Stapf. Laurent (1965), in a careful revision of the genus *Schmidtia*, treats both of the above taxa as synonyms of *S. pappophoroides* Steud.

TABLE I. CHROMOSOME NUMBERS IN PAPPOPHOREAE\*

	Root-tip	PMC	Authority
PAPPOPHORINAE			
<i>Pappophorum</i>			
<i>bicolor</i>	40, 60		Brown (1950)
"		100	Gould (1958, 1966)
<i>mucronulatum</i>	60		Brown (1950)
"		60	Gould (1966)
COTTINAE			
<i>Cottea</i>			
<i>pappophoroides</i>	20		Covas (1945)
"		<b>20</b>	
<i>Enneapogon</i>			
<i>brachystachys</i>	36		de Wet & Anderson (1956)
<i>cenchroides</i>	36		de Wet & Anderson (1956)
"		36†	Thomas (in Darlington & Wylie, 1956)
"	<b>40</b>	<b>40</b>	
<i>desvauxii</i>	20		Covas (1945)
"		20	Gould (1960, 1966)
"		20	Reeder (1967)
<i>elegans</i>		20†	Janaki-Ammal (in Darlington & Wylie, 1956)
<i>pretoriensis</i>	18		de Wet & Anderson (1956)
"	18		de Wet (1958)
<i>scoparius</i>	36		de Wet (1954, 1958)
"	36		de Wet & Anderson (1956)
<i>Kaokochloa</i>			
<i>nigrirostris</i>	<b>22</b>	<b>22</b>	
<i>Schmidtia</i>			
<i>pappophoroides</i>	36		de Wet & Anderson (1956)
"	36		de Wet (1958)
"	<b>40</b>	<b>40</b>	

\* All listed as  $2n$ . Those in boldface are new counts by the authors.

† No information as to part of plant examined.

No cytological studies have been reported thus far for the monotypic genus *Kaokochloa*. This distinctive species is apparently confined to the Kaokoveld district of South West Africa, and was described only in 1961.

In view of the fact that within the subtribe Cottinae there appeared to be two basic chromosome numbers, sometimes both within the same genus, additional cytological studies seemed desirable. Through the courtesy of B. de Winter of Pretoria, South Africa, we have recently received caryopses of *Enneapogon cenchroides*, *Schmidtia pappophoroides*, and *Kaokochloa nigrirostris* de Winter. Plants of all three species have been grown successfully in our greenhouse and experimental gar-



FIGS. 1-6. Chromosome configurations; 1, 3, 5, 6, meiotic chromosomes from Division I of microsporocytes; 2, 4, somatic chromosomes from mitosis in root-tips; 1, *Enneapogon cenchroides*, diakinesis ( $2n = 40$ ); 2, *E. cenchroides*, metaphase ( $2n = 40$ ); 3, *Schmidtia pappophoroides*, anaphase ( $2n = 40$ ); 4, *S. pappophoroides*, metaphase ( $2n = 40$ ); 5, *Kaokochloa nigrirostris*, diakinesis ( $2n = 22$ ); 6, *Cottea pappophoroides*, anaphase ( $2n = 20$ ), all  $\times 900$ .

den. Chromosomes were studied in squashes of both pollen mother cells and root-tips.

Our investigations indicate that in *Enneapogon cenchroides* the chromosome number is  $2n = 40$  (figs. 1 & 2), and not  $2n = 36$ , as reported by previous workers. Some irregularity was noted in meiosis, and univalents and multivalents were sometimes seen at diakinesis. The unexpected number of  $2n = 22$  was determined for *Kaokochloa*. Despite this, meiosis appears to be quite normal and eleven bivalents form regularly at diakinesis (fig. 5). *Schmidtia* proved to be tetraploid with  $2n = 40$  (figs. 3 & 4). This count is at variance with previous reports of  $2n = 36$  for this genus. As indicated above, although de Wet & Anderson (1956) and de Wet (1958) used the names *S. bulbosa* and *S. glabra*, Laurent (1965), in his monograph, considers both of these to be synonyms of *S. pappophoroides*.

In addition to the cytological studies reported above, we have also examined meiosis in microsporocytes of *Cottea pappophoroides* from Mexico. Our count of  $2n = 20$  (fig. 6) agrees with that given by Covas (1945), whose material came from Argentina. No irregularities were observed in meiosis.

Our cytological studies of representatives of all four genera of the subtribe Cottinae, therefore, indicate that in this group the basic chromosome number is  $x = 10$ . In one species each of *Cottea* and *Enneapogon* we found  $2n = 20$ . Tetraploid numbers of  $2n = 40$  were determined in *Schmidtia*, and a second species of *Enneapogon*. In *Kaokochloa*, it is true, we found  $2n = 22$ , but it seems reasonable to interpret this as a case of aneuploidy, and to consider that the basic chromosome number in this genus is  $x = 10$  also. In view of the close morphological and anatomical similarities between this genus and *Schmidtia*, a basic number of  $x = 11$  in *Kaokochloa* appears unlikely. A cytological reexamination of those species of *Enneapogon* in which counts of  $2n = 18$  and  $2n = 36$  have been reported seems desirable. The information on chromosome numbers in members of the Pappophoreae is summarized in Table I.

#### LIST OF SPECIES STUDIED AND SOURCES OF MATERIAL

- Cottea pappophoroides* Kunth. Mexico: Chihuahua, 23 miles NW of Zavalza, J. & C. Reeder 4587, 3 October 1966, YU.
- Enneapogon cenchroides* (Licht.) C. E. Hubbard. South Africa: Pretoria, Pyramid. Seeds from above locality supplied by B. de Winter, and plants grown in experimental garden at Yale University, J. & C. Reeder 4551, 16 July 1966, YU. Determination verified at Kew.
- Kaokochloa nigrirostris* de Winter. South West Africa: Kaokoveld. Seeds from above area supplied by B. de Winter, and plants grown in experimental garden at Yale University, J. & C. Reeder 4244, 5 July 1965, YU.
- Schmidtia pappophoroides* Steud. South West Africa: Gobabis. Seeds from above area [collected by H. Tölken] supplied by B. de Winter, and plants grown in greenhouse at Yale University, J. & C. Reeder 4821, April 1967, YU.

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## SOME ADDITIONS TO THE FLORA OF TEXAS—IV

DONOVAN S. CORRELL

As work progresses on a Manual of the vascular plants of Texas, which Marshall C. Johnston and I are engaged in preparing, additions to the flora of the state are being continually found as evidenced by those reported here and which have been reported elsewhere. (Some Additions and Corrections to the Flora of Texas. *Wrightia* 3:126–140. 1965; Some Additions and Corrections to the Flora of Texas—II. *Brittonia* 18:306–310. 1966; and —III. *Rhodora* 68:420–428. 1966). This project is being supported, in part, by a grant from National Science Foundation (GB-3138). All of the specimens cited, unless otherwise noted, are in the Lundell Herbarium (LL) of Texas Research Foundation. I wish to acknowledge the help of my wife, Helen B. Correll, in the preparation of this paper.

*SETCREASEA LEIANDRA* (Torr.) Pilg. var. ***glandulosa*** Correll, var. nov. Planta var. *leiandrae* similis; pedicelli cum pilis brevibus glanduliferis vice villorum nitidorum.

Those plants that are found about Capote Falls and along Capote Creek in Presidio Co. and have short glandular hairs on their pedicels instead of the characteristic long silky hairs are referred to this variety.

Presidio Co., on ledges of cliffs above Capote Falls, in clumps, perennial, Nov. 3, 1966, *D. S. Correll* 34128 (holotype, LL); Capote Creek, Sept. (Oct.) 1883, *V. Havard* 79 (GH, US).

***Nolina arenicola*** Correll, sp. nov. Caulis florifer ad 1 m altus (infrascripta includenti); folia numerosa caespitem magnum formantia, circa 1.3 m longa, 5 mm lata, complanata vel concavo-convexa, marginibus rasilibus; panícula composita, aliquantum aperta, ramis grossis effusis vel patulo-ascendentibus; rami cum ramulis curtis; bractae non conspicuae, plerumque ramos primarios fere aequantes vel leviter superantes; perianthium 2.5–3.5 mm longum, segmentis ovato-ellipticis; fructus 4–7 mm lati, cum incisura profunda ad apicem; stylus prominens; pedicelli fructiferi 5–7 mm longi, prope basim articulati in fruc-

tus dilatati, cum cristis prominentibus sub fructibus; semina 4–6 mm diametro.

Flowering stem up to 1 m high (including the inflorescence); leaves numerous to form a large clump, about 1.3 m long and 5 mm wide, flat or concave-convex, with smooth margins; panicle compound, rather open with coarse spreading or spreading-ascending branches, the branches with short stubby branchlets; bracts not conspicuous, mostly about equal to or only slightly exceeding the primary branches; perianth 2.5–3.5 mm long, the segments ovate-elliptic; fruits 4–7 mm wide, deeply notched at apex, the style prominent; fruiting pedicels 5–7 mm long, articulate near base, dilated into the fruit, with prominent ridges just under the fruits; seeds 4–6 mm. in diameter.

Culberson Co., in dunes, 18 miles east of Van Horn, on route U.S. #80, July 24, 1957, *D. S. Correll & I. M. Johnston 18445* (holotype, LL); sandy plain, scrub land, 17 miles east of Van Horn, scape 3 ft. tall, plants forming a large bunch, July 30, 1958, *D. S. Correll & I. M. Johnston 20360*.

This species is most closely allied to *N. texana* S. Wats. It is, however, a much coarser plant than that species. Its coarsely branched open panicle resembles that of *N. erumpens* (Torr.) S. Wats. but the long pedicels and smooth-margined leaves readily separate it from that species. This species seems to occur only in sandy instead of the usually rocky or clayey soils of most of our species.

*NOLINA MICRANTHA* I. M. Johnst., Jour. Arn. Arb. 24: 91. 1943. Culberson Co., on rocky slopes near Pine Springs, Guadalupe Mts., inflorescence shorter than the leaves, July 25, 1957, *D. S. Correll & I. M. Johnston 18473*; same locality and date, male plant, *D. S. Correll & I. M. Johnston 18518*; on limestone hill, off highway #62, near Frijole, Guadalupe foothills, acaulescent, inflorescence pinkish, Aug. 8, 1945, *C. L. Lundell & Amelia A. Lundell 14372*. Hudspeth Co., on Keeling's Ranch, Sierra Diablo, 12 miles north of Allamore, in clumps, grasslands, June 9, 1964, *D. S. Correll, H. S. Gentry, & Craig Hanson 29769, 29774*.

This northern Mexican species is new to Texas and the United States. The slenderly dissected and somewhat twiggy inflorescence, slender short pedicels, and the typically purplish or reddish purple tinged main rachis, branches and branchlets, and bracts are distinguishing characteristics of this species. It is quite different from any other species that we have in Texas.

*YUCCA CARNEROSANA* (Trel.) McKelvey, Yuccas Southw. U. S. 1:24, pls. 6 and 7. 1938.

Culberson Co., McKittrick Canyon, Guadalupe Mts., a few plants scattered on sides of canyon, distinguished by their trunks covered with reflexed leaves, no flowers seen, July 25, 1957, *D. S. Correll & I. M. Johnston 18497*; south fork of McKittrick Canyon, Guadalupe Mts.,

tall multi-trunked plant with showy heads of white flowers, up to 15 ft. tall, Apr. 20, 1962, *D. S. Correll & E. C. Ogden 25057*.

In 1938, McKelvey gave the area of distribution of this species in the United States as, "Confined to Brewster Co., Texas, where it extends from the mountainous regions about Boquillas on the Rio Grande northward to slightly beyond Persimmon Gap in the Santiago Mts." Webber (in *Yuccas of the S. W., U.S.D.A. Agr. Mon. No. 17:18*, 1953) did not enlarge the range of this species given by McKelvey. Apparently it has never been reported outside of Brewster County in the United States. Its locality about and just below the mouth of McKittrick Canyon is only a few miles from New Mexico. It is surprising that so spectacular a plant as this escaped notice before now in the Guadalupe Mountains which have been botanized by numerous botanists through the years. Several old plants, some 15 feet high or more, are scattered in the open scrub forest and chaparral.

ANENOME EDWARDSIANA Tharp var. **petraea** Correll, var. nov. Varietas *petraea* habitu cum var. *edwardsiana* congruens sed receptaculis et acheniis omino glabris et vernicosis.

In habit similar to var. *edwardsiana* but with completely glabrous and vernicose achenes and receptacle. The plants grow so tightly embedded in rock crevices that it is almost impossible to obtain rootstocks.

Kendall Co., in crevices of boulders in canyon below falls, Edge Falls, between Kendalia and Bergheim, Mar. 31, 1965, *D. C. Correll & Helen B. Correll 30743* (holotype, LL); in crevices of ledges near Edge Falls, along Curry Creek, 5 miles south of Kendalia, April 14, 1964, *D. S. Correll 29141*.

*Anemone edwardsiana* is apparently an endemic species on the Edwards Plateau and is not referable to the Coloradan *A. tuberosa* Rydb. where some recent authors have tended to place it.

RANUNCULUS SARDOUS Crantz, Stirp. Austr. ed. 1 fasc. 2. 84. 1763.

Panola Co., grassy soil, small lake on Alexander Ranch about 4 miles north of Deadwood, flowers yellow, May 9, 1962, *D. S. Correll & E. C. Ogden 25188*.

This is apparently the first report of this Old World species in Texas. Lyman Benson kindly identified this collection.

CRATAEGUS PEARSONII Ashe, Jour. Elisha Mitchell Sci. Soc. 17:10. 1900.

Jasper Co., south of Jasper off highway 96 between road to Magnolia Springs and road to Roganville, east side of road in woodlands, small trees, Apr. 14, 1963, *D. S. Correll & Helen B. Correll 27231*; about 7 miles south of Jasper, pine-hardwood forest on Kirbyville road, small tree about 15 ft. tall, flowers white, Apr. 10, 1964, *D. S. Correll & Helen B. Correll 29109*; in mixed forest south of Jasper, tree 15 ft. high, 3 in. in diameter, Apr. 15, 1942, *C. L. Lundell & Amelia A. Lundell 11191*; in high forest south of Jasper, armed shrub 10 ft. tall, Sept. 9, 1942, *C. L. Lundell & S. W. Geiser 11819, 11823*.



This species of hawthorn is new to Texas. It has heretofore been known to occur in Mississippi and Louisiana. It is one of the most distinctive species in this extremely complex genus, and it is the only representative of Series Flavae in our region. This Series is characterized by the conspicuous glands of the inflorescence and on the leaf-teeth and petioles. The mature leaves are also characteristic in having a broad subtruncated apex.

CORNUS RACEMOSA Lam., *Encycl.* 2:116. 1786.

Bowie Co., in wooded seepage, along McKinney Bayou, on Summerhill Road #1397, 6.5 miles north of Texarkana, fruits green, pith brown, Aug. 14, 1966, *D. S. Correll 33420*; same locality, fruits white, pith white, *D. S. Correll 33419*; same locality, small trees to 12 ft. high, fruits white, pith white, Aug. 30, 1966, *D. S. Correll 33587*. Cass Co., edge of low forest, about 1.5 miles east of McLeod, small tree to 9 ft. tall, pith dull white, Sept. 14, 1964, *D. S. Correll 30097*.

This species of dogwood is new to Texas. There are several small colonies in the northeast counties noted above.

NAMA DICHOTOMUM (R. & P.) Choisy in DC., *Prodr.* 10:182. 1846.

Jeff Davis Co., in gravelly bare soil near summit of Mt. Livermore, Davis Mts., flowers pale lavender, Sept. 20, 1966, *D. S. Correll 33744*.

According to Lincoln Constance, who kindly contributed a treatment of the Hydrophyllaceae to our MANUAL, this is apparently the first report of this species from Texas.

**Proboscidea crassibracteata** Correll, sp. nov. Herba annua, ampla, procumbens, ad 1.5 dm lata et ad 5 dm alta, omino glanduloso-pubescent; caulis crassus et gravis; folia petiolis gracilibus ad 2.5 dm vel pluribus longis, late triangulo-ovata vel suborbiculato-ovata, cordata, rotundata vel ad apicem obtusa, ad 1.5 dm vel plura longa, longitudo foliorum latitudinem aequans, margine grosse sinuato; flores plures, in racemo brevi gracili ad 10 cm longo prodientes; racemus foliis brevior; pedicelli aliquantum crassi, 2–3 cm longi; bracteae 2, ovato-ellipticae in circumstriptione, obtusae, conspicue carnosae-crassae, circa 8 mm longae et 3.5 mm latae, 2 mm crassae, concavae; calyx tenui-herbaceus, circa 1.5 cm longus, ad apicem irregulatum 5-lobatus, ad basim ventraliter fissus; corolla tubulari-campanulata, non nisi leviter ventricosa; corollae tubus roseus, circa 4 mm supra basim constrictus, extra sparsim pilosus, circa 2.5 cm longus, orificio 1–1.5 cm lato; faux secus medium lineis paucis croceis et ad ostium pilis brevibus articulatis; corollae lobi 5, subaequales, semiorbiculares, late rotundati, sinibus angustis 4–5 mm profundis, lobo medio luteolo circa 2 cm late ubi expanso; capsulae corpus ellipsoideum, ventrali valde carinatum, 8–9 cm longum, circa 2 cm latum, supra in cornu validum arcuatum, longitudine corporis duplo longius protractum.

Plants large, annual, sprawling, as much as 1.5 m across and up to 5 dm high, the herbage glandular-pubescent throughout; stem thick and



heavy; leaves with slender petioles up to 2.5 dm long or more, broadly triangular-ovate to suborbicular-ovate, cordate, rounded to obtuse at apex, up to 1.5 dm long or more, about as wide as long, the margins coarsely sinuate; flowers several, borne in a short slender raceme up to 10 cm long that is overtopped by the leaves; pedicels rather stout, 2–3 cm long; bracts 2, ovate-elliptic in outline, obtuse, conspicuously fleshy-thickened, about 8 mm long and 3.5 mm wide, 2 mm thick, concave so as to conform with the calyx; calyx thin-herbaceous, about 1.5 cm long, irregularly 5-lobed at apex, ventrally split to the base; corolla tubular-campanulate, only slightly ventricose; corolla-tube noticeably constricted about 4 mm. above base, pink, sparsely pilose without, about 2.5 cm long, 1–1.5 cm wide across orifice, the throat with a few yellow lines along the middle and some short articulate hairs at its mouth; corolla-lobes 5, subequal, semiorbicular, broadly rounded, the narrow sinuses 4–5 mm deep, the middle lower lobe yellowish, about 2 cm across the lobes when spread out; fruit-body ellipsoid, strongly keeled on the ventral side, 8–9 cm long, about 2 cm thick, tapered above into a stout curved horn that is about twice as long as the body.

Presidio Co., on clay flats near Adobes, Rte. No. 170, flowers pink, with yellow line in throat, Sept. 25, 1966, *D. S. Correll 33900* (holotype, LL).

***Galium frankliniensis*** Correll, sp. nov. Planta omnino dense hispidula; caules principales e base densa lignea et saepe cum caule prostrato ligneo cortice brunneola; caules aërii manifeste 4-angulati, plerumque porcato-erecti vel ascendentes, ad 3 dm alti; folia 4 in verticillum, sessilia, elliptica vel elliptico-oblongata, obtusa vel acuta et ad apicem cuspidata, ad 8 mm longa et 3 mm lata, marginibus aliquantum revolutis, costa aliquantum carinata infra medium infra; flores perfecti, quasi sessiles, raro pedunculo brevi nudo, plerumque in ramis brevissimis inflorescentiam ramorum compactorum supra partem foliaceam caulis extensorum facientes; corolla plerumque brunneo-violacea, circa 1.5 mm lata; fructus pilis rectis albis dense velati diametrum fructus aequantibus.

Plant densely hispidulous throughout; main stems from a heavy woody base and often with a prostrate woody stem with brownish bark; aerial stems prominently 4-angled, usually rigidly erect or ascending, up to 3 dm high; leaves in whorls of 4, sessile, elliptic to elliptic-oblongate, obtuse to acute and cuspidate at apex, up to 8 mm long and 3 mm wide, the margins somewhat revolute, the central vein somewhat keeled below the middle on the lower surface; flowers perfect, sessile or essentially so, rarely on a short naked peduncle, usually on very short branches to form an inflorescence of compact branches that stand rigidly above the leafy portion of stem; corolla mostly brownish purple, about 1.5 mm across; fruits densely covered with straight whitish hairs that are about as long as the diameter of the fruit.

El Paso Co., rock crevices, McKelligon Canyon, Franklin Mts., near

El Paso, flowers brown-purple, Aug. 13, 1946, *D. S. Correll 13837* (holotype, SMU); rare perennial in sandstone ledges of McKelligon Canyon, Franklin Mts., July 16, 1949, *B. L. Turner 1286* (SMU); infrequent perennial on east lower limestone slopes of Franklin Mts., El Paso, Apr. 19, 1952, *B. H. Warnock 10422*; infrequent low herb, limestone soil, east lower slope along the arroyos of the Franklin Mts., about 7 miles from El Paso toward the White Sands, Sept. 29, 1956, *B. H. Warnock 14291*.

Lauramay T. Dempster, of the University of California, was kind enough to examine these specimens, and, as she pointed out, they are most closely related to *G. parishii* H. & H., of California and Nevada. The hispidulous indument and elliptic to elliptic-oblong leaves of *G. frankliniensis* are quite different from that species.

SPERMACOCE FLORIDANA Urban, Symb. Antill. 7:550. 1913. *Spermacoce portoricensis* A. Gray, Syn. Fl. 1, pt. 2. 34. 1884; Small, Fl. Southeast. U. S. 1117. 1903, *non* Balb.

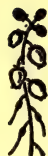
Cameron Co., in Palm Grove, Mar. 9, 1942, *C. L. Lundell 10645* (LL, TEX); July 1942, *A. M. Davis s.n.* (TEX).

This species, which heretofore has been known from Florida and the West Indies, is new to Texas. It differs from *S. tenuior* L., its nearest ally in Texas, in that its corolla is essentially glabrous within instead of being noticeably pubescent, and its subglobose glabrous fruit is 1–1.5 mm long in contrast to the didymous-obovoid mostly puberulent fruit of *S. tenuior* which is 2–2.5 mm long.

Texas Research Foundation, Renner

## NOTES AND NEWS

LIBRARY MAILING RATES FOR HERBARIUM SPECIMENS.— Congress, in its recently passed postal bill, enlarged the concept of library mailing rates to include herbarium specimens as well as other kinds of systematic collections (Sect. 135.14, *Postal Manual*). Specimens sent at library rates must be addressed to an institution, not to an individual, but the package may be marked to the attention of an individual at an institution. Packages cannot exceed 70 pounds each nor a length plus girth of more than 72 inches. In view of the low cost of sending herbarium specimens at this rate, I suggest that we send domestic loans prepaid. It will save us all money in the long run.—JOHN H. THOMAS, Dudley Herbarium, Stanford University.



# MADROÑO

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## NEW TAXA, COMBINATIONS, AND CHROMOSOME NUMBERS IN ARCTOSTAPHYLOS (ERICACEAE)

PHILIP V. WELLS

*Arctostaphylos* is a predominantly Californian genus of woody plants with more than 100 described taxa. About half of these are based on questionable or trivial differences or do not exist as discrete natural populations. The remainder are well defined entities distinguished by numerous morphological and ecological criteria. It must be admitted that the mixture of well and ill defined taxa, which were practically all proposed at the specific level, and the prevalence of hybridization, have made *Arctostaphylos* a *bête noire* for many botanists. This has not, however, discouraged work on the genus (Abrams, 1914; 1951; Adams, 1940; Eastwood, 1934; Howell, 1945; Jepson, 1922; 1923; 1925; 1939; McMinn, 1939; Munz, 1959; Schreiber, 1940). Each student has contributed to the character analysis, yet much remained, and still remains, to be learned about phenetic patterns in *Arctostaphylos*.

After a period of nomenclatorial quiescence, there has been a renewed flurry of activity in recent years (Gankin, 1966; 1967; Hoover, 1964; Hoover and Roof, 1966; Roof, 1962; 1964; 1967; Wells, 1961; 1965). The law of diminishing returns seems to be taking effect, but two new species, a number of infraspecific taxa, and a number of new combinations seem logical.

I carried out a cytotaxonomic survey (Table I) of many of the species of *Arctostaphylos* during the academic year, 1966–1967, thanks to research facilities and funds in the Department of Botany, University of California. My thanks are also due to G. Ledyard Stebbins for his information and encouragement which served as a stimulus in the present survey, to Marion Cave for her help with cytological preparations, to my industrious assistant, Pat Watters, to T. F. Niehaus for fixed material of some species, and to H. G. Baker, James B. Roof, and Walter Knight for the many discussions of *Arctostaphylos* that I inflicted upon them.

### A NEW MANZANITA FROM SANTA CATALINA I.

*Arctostaphylos catalinae* P. V. Wells, sp. nov. Frutex erectus, arborescens, 2–6 m altus; caudex etumescens; cortex levis ruber; ramuli glandulosi, plerumque setosi pilis albis; folia virida, sparseque glandulosa ad basim, ovata oblongave, apice acuta obtusave, stomatifera supra et infra, basi truncata cordatave, interdum hastata auriculatave; petioli 2–6 mm longi; inflorescentia paniculata, ramuli saepe 5–6; bractae foliaceae triangulato-lanceolatae, hispidociliatae, dense imbricatae in nascentis inflorescentiis; pedicelli glandulosi; corolla 7–10 mm longa; ovarium dense pilosum et sparse glandulosum; drupa glabrata, cinnamomea.

Holotype: eroded andesitic bedrock slopes at head of Bulrush Canyon, Santa Catalina I., Los Angeles Co., California, *P. V. Wells 6867*, UC.

Tall, erect, arborescent shrub, 2–6 m high, with a well defined trunk and without basal burl. Rare individuals near Haypress show a few weak sprouts from the base of the trunk, but no burl, which may reflect a crown-sprouting ancestry. However, at present *A. catalinae* is a species of the obligately seeding type. Bark smooth, red-brown. Branchlets densely short hispid and with longer setose hairs, most of the hairs at first gland-tipped. Leaves ovate or oblong, acute; base of leaf polymorphic, varying from subcordate to strongly cordate or sometimes with vestigial auriculation or hastation, to truncate, obtuse or tapering in the same population, on petioles 2–6 mm long; blades light green, glandular-ciliate towards the base, along the margin and on the midrib, otherwise glabrous; stomatal distribution isofacial, with stomata above and below. Leaf morphology suggests a common ancestry with a member of the auriculate-leaved group, such as *A. viridissima* of Santa Cruz I. Inflorescence large, openly paniculate with as many as 5–6 branches from the main rachis; bracts leafy, with a characteristic isoceles-deltoid to lanceolate shape, densely imbricated in the nascent inflorescence, much longer than the very short pedicels which average 2–3 mm in length; rachis and pedicels glandular-hispidulous, bracts glandular-ciliate. Corolla 7–10 mm long, white or suffused with pink; ovary densely white-hairy and with sparse gland-tipped hairs; fruit oblate-spheroidal, glabrescent, orange-brown, on straight pedicels; nutlets separable.

This species has been identified as *A. glandulosa* Eastw., *A. subcordata* Eastw., *A. viridissima* (Eastw.) McMinn, or *A. insularis* Greene; in other words, it has been confused with nearly all of the species which occur on the Channel Islands. It combines the characters of the last three of the above mentioned species, none of which presently occur on Santa Catalina I. It differs from *A. tomentosa* ssp. *subcordata* of Santa Cruz I. and *A. glandulosa* of the mainland in being an erect, arborescent shrub, lacking a basal burl. *Arctostaphylos tomentosa* ssp. *subcordata* and *A. glandulosa* are burl-forming, crown-sprouting species which usually produce shrubby colonies; also *Arctostaphylos catalinae* has a larger, more branched inflorescence than the burl-formers. Some individuals of *A. catalinae* show vestigial auriculation or hastation of the leaf-base, many others have cordate leaves and most have the leaves more or less imbricated, as in *A. viridissima* of Santa Cruz I. The ample inflorescence and orange-brown, glossy fruits of *A. catalinae* are traits shared with *A. insularis* of Santa Cruz I. It is *A. confertiflora* Eastw. of Santa Rosa I. which resembles *A. catalinae* more closely than any other known species. Contrary to published descriptions (Howell, 1945; Munz, 1959), *A. confertiflora* has isofacial leaves and appears to lack a basal burl. Howell and I established the stomatal distribution on the type specimen (CAS), which was previously thought to have bifacial leaves. Also, a chromosome count indicates that *A. confertiflora* is diploid ( $n = 13$ ). Hence it is

asserted that *A. confertiflora* of Santa Rosa I. is specifically distinct from *A. tomentosa* ssp. *subcordata* of Santa Cruz I. with which it usually has been placed as a variety or in subjective synonymy; *A. tomentosa* ssp. *subcordata* is a bifacial, burl-forming tetraploid ( $n = 26$ ). *Arctostaphylos catalinae* differs from *A. confertiflora* in at least eight characters given in the following key.

KEY TO THE MANZANITAS OF THE CHANNEL ISLANDS

Bracts of the inflorescence subulate, not leafy; nascent inflorescence with very slender, thread-like minutely-bracted branches; stomata restricted to lower surface of leaves; basal burl lacking; fruit bright orange-brown; endemic to Santa Cruz I., on volcanic and metamorphic rocks . . . . . *A. insularis* Greene

Bracts of inflorescence leafy, lanceolate, deltoid or ovate; nascent inflorescence not filiform, its rachis-branches thick with imbricated foliaceous bracts.

Basal burl present, shrubs crown-sprouting; leaves bifacial, stomata and tomentum restricted to lower surface of blade.

Branchlets, petioles, rachis, bracts, and pedicels glandular-hairy; bodenvag, Santa Cruz I. . . . . *A. tomentosa* ssp. *subcordata* (Eastw.) Wells

Branchlets, petioles, and inflorescence tomentose, not glandular; Santa Cruz and Santa Rosa islands, chiefly on volcanic rocks.

*A. tomentosa* ssp. *insulicola* Wells

Basal burl absent, not crown-sprouting; leaves isofacial, stomata on both surfaces.

Leaves auriculate-clasping, short-petioled to nearly sessile; branchlets, petioles, rachis, and bracts densely hispidulous and setose with long white hairs, not glandular; ovary and pedicels tomentose, not glandular; Santa Cruz I., bodenstet on siliceous shale . . . . . *A. viridissima* (Eastw.) McMin

Leaves cordate to truncate, distinctly petioled, not auriculate-clasping; branchlets, petioles, rachis, and bracts densely glandular-hairy; ovary and pedicels tomentose and sparsely glandular.

Bracts broadly ovate; inflorescence compact, crowded, with 3-4 branches from main rachis; sepals glandular-ciliate; corolla 5-6 mm long; indument of branchlets and inflorescence glandular-hispid, not long-setose; leaves broadly round-ovate; fruit dull reddish brown; endemic to Santa Rosa I. . . . . *A. confertiflora* Eastw.

Bracts narrowly isosceles-deltoid to lanceolate; inflorescence more open, with 5-6 branches from main rachis; sepals not glandular-ciliate; corolla 7-10 mm long; indument of branches and inflorescence glandular-hispid and also long-setose with white hairs; leaves oblong-ovate; fruit bright orange-brown; endemic to Santa Catalina I., chiefly on volcanic rocks.

*A. catalinae* Wells

A NEW AURICULATE-LEAVED MANZANITA FROM SANTA BARBARA CO.

*Arctostaphylos purissima* P. V. Wells, sp. nov. Frutex erectus, arborescens, 1-5 m altus, interdum prostratus in situ extremo; caudex etumescens, cortex levis, ruber; ramuli hispiduli plerumque setosi pilis albis; folia virida, circinata-ovata, 1-2 cm in diametro,  $\pm$  sessilia, basi auriculata, apice obtusa acutave, stomatifera supra et infra; inflorescentia densa, ramuli 0-3; bracteae foliaceae ovatae, marginibus hispido-ciliatis; pedicelli glabri, 3 mm longi; corolla globosa, 5-6 mm longa; ovarium glabrum; drupa 5-8 mm in diametro.

Holotype: on Pleistocene sands, west side of La Purisima ridge, Santa Barbara Co., California; *Wells 610671*, UC.



Tall, erect, arborescent shrub with a well defined trunk, to over 5 m high in canyons, but sometimes nearly prostrate or forming low mounds on windswept mesa tops near the coast; without basal burl; bark smooth, red-brown; branchlets, rachis and bracts densely hispidulous and setose with white hairs, not glandular; leaves isofacial, closely imbricated, round or round-ovate, relatively small, about 1–2 cm in diameter, nearly sessile or on very short petioles, auriculate-clasping, obtuse or rounded to acute at the apex; leaves bright green with red margins, or on new growth deep crimson-red throughout; inflorescence very compact, simple or with 1–3 branches; lower bracts broadly ovate, foliaceous, hispidociliate on the margins, densely imbricated in the nascent inflorescence; pedicels much shorter than the subtending bracts, ca. 3 mm long; corolla globose, 5–6 mm long; pedicels, ovary and fruit glabrous; fruit oblate-spheroidal, 5–8 mm in diameter, the nutlets separable.

*Arctostaphylos purissima* has suffered a fate similar to that of *A. luciana*: lack of recognition due to weighing of the auriculation character. It seems that in a difficult genus there is a tendency to achieve order by weighting conspicuous characters. All entities possessing the trait are made conspecific, as subspecies or even synonyms. This approach to *Arctostaphylos* taxonomy was pioneered by Jepson (1922; 1923; 1925; 1939), who regarded all auriculate-leaved manzanitas as varieties of *A. andersonii* Gray. The distinguishing characters of *A. purissima* have been consistently overlooked by botanists, including Wells (1965). After observing *A. viridissima* on Santa Cruz I. in 1967, it became obvious that it is distinct from *A. pechoensis* and from *A. purissima*, which for years has been called *A. viridissima*. The three species share some striking characters, but they are readily distinguished by a number of other characters, and have allopatric distributions. Chromosome counts of these and other species of the auriculate-leaved group indicate that all are diploid ( $n = 13$ ). The following key includes six species occupying disjunct areas from the southern extremity of the Santa Lucia range south to Santa Cruz I.

#### KEY TO AURICULATE-LEAVED MANZANITAS OF SOUTHERN CALIFORNIA

Fruit oblate-spheroidal, not apiculate; nutlets separable, not coalesced as a single stone; branchlets and pedicels not glandular.

Branchlets and rachis canescent or tomentose, without setose hairs; inflorescence paniculate.

Leaves and bracts gray-canescant, the bracts not hispid or ciliate; ovary glabrous; flowering pedicels glabrous, 6–7 mm long, strongly recurved in fruit; nascent inflorescence campanulate-cernuous; flowering panicle ample, openly branched; San Luis Obispo Co., on siliceous Monterey shale in the Santa Lucia Mountains, chiefly southeast of Cuesta Pass. . . . *A. luciana* Wells

Leaves and bracts green, not canescent; bracts hispidociliate on the margin; ovary densely pubescent; flowering pedicels pubescent, 4–5 mm long, straight or recurved fruit; nascent inflorescence not as above; flowering panicle dense, compactly branched; San Luis Obispo Co. north to s. Monterey Co., Pleistocene sands along the coast . . . . *A. cruzensis* Roof

Branchlets and rachis hispidulous and densely setose with long white hairs; bracts hispidociliate; inflorescence compact, simple or with one or two branches.



Lower bracts broadly ovate; leaves green, not glaucous, round to round-ovate, 1–2 cm in diameter; fruit 5–8 mm in diameter; pedicels very short, 3 mm long, not recurved in fruit; ovary and pedicels glabrous; corolla globose, 5–6 mm long; Santa Barbara Co., La Purisima area and Burton Mesa north to Pt. Sal, on diatomite, siliceous shale and Pleistocene sands.

*A. purissima* Wells

Lower bracts lanceolate to linear; leaves ovate to oblong-ovate, 2–4 cm long; fruit 10–15 mm in diameter.

Ovary and pedicels densely pubescent; corolla globose, 5–6 mm long; pedicels very short, 3 mm long, not recurved in fruit; leaves green, not glaucous; Santa Cruz I., on siliceous shale . . . *A. viridissima* (Eastw.) McMinn

Ovary and pedicels glabrous; corolla conical-urceolate, 7–8 mm long; pedicels 8–9 mm long, varying from straight to recurved in fruit; leaves green, but thinly glaucous with a whitish wax which is readily erased; San Luis Obispo Co., Pecho Hills sector of the San Luis Range, on Monterey shale.

*A. pechoensis* Dudley

Fruit round or ovoid, apiculate, 10–15 mm in diameter; nutlets coalesced as a solid stone, not separable; branchlets glandular-hispid and setose with gland-tipped hairs; pedicels glandular-puberulent; corolla 8–10 mm long; inflorescence an ample, openly-branched panicle; Santa Barbara Co., vicinity of Refugio Pass, on sandstone. . . . . *A. refugioensis* Gankin

#### INFRASPECIFIC TAXA OF ARCTOSTAPHYLOS TOMENTOSA

ARCTOSTAPHYLOS TOMENTOSA (Pursh) Lindley ssp. *insulicola* P. V. Wells, ssp. nov. A ssp. *tomentosa* differt: cortex levis ruber, non-laciniosus.

Holotype: terrace on basaltic rocks above Pelican Bay, Santa Cruz I., Santa Barbara Co., California, *P. V. Wells & J. B. Roof 5467*, UC.

Tall shrubs to more than 3 m high, taller than ssp. *tomentosa*; bark smooth, bright red-brown; inflorescence an ample, open panicle.

This subspecies is restricted to Santa Cruz and Santa Rosa islands. The largest known population is on basalt at Pelican Bay; on other types of rocks on Santa Cruz I., ssp. *subcordata* predominates. Extensive intergradation between the two subspecies occurs in some parts of the island. However, on Santa Rosa I., ssp. *insulicola* is allopatric from other subspecies of *A. tomentosa*.

ARCTOSTAPHYLOS TOMENTOSA (Pursh) Lindley ssp. *eastwoodiana* P. V. Wells, ssp. nov. A ssp. *tomentosa* differt: cortex levis ruber, non-laciniosus; ovarium glabrum; pedicelli glabri; folia glabra.

Holotype: on diatomite, summit of La Purisima ridge, Santa Barbara Co., California, *P. V. Wells 610672*, UC.

Eastwood was one of the first to comment on this entity (Roof, 1964), which she correctly perceived as a close relative of *A. rosei* Eastw. It is fitting to honor her name in *Arctostaphylos* in which she described so many taxa, in fact, threefold more than any contemporary author.

In Pine Canyon, on Burton Mesa, some individuals of ssp. *eastwoodiana* have the leaves tomentulose below, and/or with sparsely pubescent ovary and pedicels; hence these individuals are phenetic intergrades with ssp. *insulicola* of the Channel Islands or with ssp. *rosei* of the central California coast.

The description of two new subspecies of *A. tomentosa* requires a change in rank of several similar and intergrading taxa.

ARCTOSTAPHYLOS TOMENTOSA (Pursh) Lindley ssp. *rosei* (Eastw.) P. V. Wells, comb. nov. *A. rosei* Eastw., Leafl. West. Bot. 1:77. 1933; *A. crustacea* var. *rosei* (Eastw.) McMinn, Ill. Man. Calif. Shrubs 413. 1939.

Subspecies *rosei* differs from ssp. *tomentosa* in having glabrous leaves and reddish, not gray bark. It is allopatric from ssp. *insulicola* and ssp. *eastwoodiana*, but contacts and intergrades with ssp. *tomentosa* and ssp. *crustacea* on the Monterey Peninsula and at Lake Merced, respectively (Roof, 1964).

ARCTOSTAPHYLOS TOMENTOSA (Pursh) Lindley ssp. *crustacea* (Eastw.) P. V. Wells, comb. nov. *A. crustacea* Eastw., Leafl. West. Bot. 1:74. 1933.

Subspecies *crustacea* intergrades with ssp. *rosei* at Lake Merced, with ssp. *eastwoodiana* at Pt. Sal, and grades clinally into ssp. *tomentosiformis* in the Santa Cruz Mountains.

ARCTOSTAPHYLOS TOMENTOSA (Pursh) Lindley ssp. *tomentosiformis* (Adams) P. V. Wells, comb. nov. *A. tomentosa* var. *crinata* McMinn, Ill. Man. Calif. Shrubs 412. 1939 (without Latin diagnosis); *A. crustacea* var. *tomentosiformis* Adams, Jour. Elisha Mitchel Soc. 56:54. 1940; *A. tomentosa* var. *tomentosiformis* (Adams) Munz, Aliso 4:95. 1958.

The nomenclatural history of this subspecies reflects its taxonomic position: intermediate between ssp. *crustacea* and ssp. *tomentosa*. It occupies a geographic position between the other two subspecies in the Santa Cruz Mountains and intergrades extensively there with ssp. *crustacea*.

ARCTOSTAPHYLOS TOMENTOSA (Pursh) Lindley ssp. *subcordata* (Eastw.) P.V. Wells, comb. nov. *A. subcordata* Eastw. Leafl. West. Bot. 1:61. 1933.

Some of the intermediates between ssp. *insulicola* and ssp. *subcordata* in the polymorphic populations on Santa Cruz I. have non-glandular, setose hairs and therefore present a combination of characters resembling the disjunct ssp. *tomentosiformis*. Except for the lack of gray, shreddy persistent bark, typical ssp. *subcordata* closely resembles ssp. *tomentosa* f. *trichoclada*.

ARCTOSTAPHYLOS TOMENTOSA (Pursh) Lindley ssp. TOMENTOSA f. *trichoclada* (DC.) P. V. Wells, comb. nov. *Andromeda bracteosa*  $\beta$  *trichoclada* D.C., Prod. 7(2):607. 1839; *Arctostaphylos bracteosa* (DC.) Abrams, Leafl. West. Bot. 1:84. 1934; *A. tomentosa* ssp. *bracteosa* (DC.) Adams, Jour. Elisha Mitchell Soc. 56:57. 1940; *A. tomentosa* var. *trichoclada* (DC.) Munz, Aliso 4:96. 1958.

A glandular form, f. *trichoclada*, occurs within populations of ssp. *tomentosa* on the Monterey Peninsula and is distinguished by the glandular-setose pubescence of the inflorescence and branchlets. Various degrees of intermediacy exist between f. *trichoclada* and f. *tomentosa*,

but the prevalence of both extreme forms in most populations is suggestive of balanced polymorphism. Furthermore, the intensely glandular species, *A. montereyensis* Hoover, which is sympatric with *A. tomentosa* near Monterey, is a likely source of genes for glandulosity.

ARCTOSTAPHYLOS TOMENTOSA (Pursh) Lindley ssp. TOMENTOSA f. *hebeclada* (DC.) P. V. Wells, comb. nov. *Andromeda bracteosa*  $\beta$  *hebeclada* DC., Prod. 7(2):607. 1839; *Arctostaphylos bracteosa* var. *hebeclada* (DC.) Eastw., Leaf. West. Bot. 1:122. 1934; *A. tomentosa* var. *hebeclada* (DC.) McMinn, Ill. Man. Calif. Shrubs 412. 1939.

This is another intrapopulation form of ssp. *tomentosa* on the Monterey Peninsula; it has leaves which are glabrescent on the lower surface, as in ssp. *rosei*. However, the gray bark distinguishes it from the latter subspecies.

#### KEY TO THE INTRASPECIFIC TAXA OF ARCTOSTAPHYLOS TOMENTOSA

Surficial bark gray and persistent as flat shreds, underbark reddish-brown.

Pubescence of branchlets and inflorescence tomentose, not glandular.

Leaves tomentose on lower surface; Monterey Peninsula and disjunctly south to Los Osos Valley, San Luis Obispo Co.

*A. tomentosa* ssp. *tomentosa* f. *tomentosa*

Leaves glabrescent; Monterey Peninsula

*A. tomentosa* ssp. *tomentosa* f. *hebeclada* (DC.) Wells

Branchlets and inflorescence with glandular-setose hairs; Monterey Peninsula.

*A. tomentosa* ssp. *tomentosa* f. *trichoclada* (DC.) Wells

Surficial bark bright reddish-brown, smooth or shreddy.

Branchlets and inflorescence with glandular-setose hairs; bark smooth; Santa Cruz

I. . . . . *A. tomentosa* ssp. *subcordata* (Eastw.) Wells

Indumentum not glandular.

Branchlets and inflorescence setose with long white hairs; bark smooth.

Leaves tomentose below; Santa Cruz Mountains.

*A. tomentosa* ssp. *tomentosiformis* (Adams) Wells

Leaves glabrate below; San Francisco Bay area south to Santa Barbara Co.

*A. tomentosa* ssp. *crustacea* (Eastw.) Wells

Indumentum not setose.

Leaves tomentose below; bark smooth; Santa Cruz and Santa Rosa islands.

*A. tomentosa* ssp. *insulicola* Wells

Leaves glabrous.

Ovary and pedicels tomentose; bark more or less shreddy-persistent, but reddish-brown, not gray; San Francisco Bay area south to s. Monterey Co. . . . . *A. tomentosa* ssp. *rosei* (Eastw.) Wells

Ovary and pedicels glabrous or glabrescent; bark smooth; La Purisima ridge n. to Pt. Sal, Santa Barbara Co.

*A. tomentosa* ssp. *eastwoodiana* Wells

#### A NEW SUBSPECIES OF ARCTOSTAPHYLOS PILOSULA

ARCTOSTAPHYLOS PILOSULA Jeps. & Wiesel. ssp. *pismoensis* P. V. Wells, ssp. nov. A ssp. *pilosula* differt: frutex arborescens, 2–5 m altus; folia virida, elliptica lanceolatae, basi acuta circinatae; pedicelli 3–6 mm longi.

Holotype: on Pismo sandstone, 3 miles southwest of Edna, San Luis Range, San Luis Obispo Co., California, P. V. Wells 23, UC.



Tall arborescent shrub to more than 5 m high; leaves green, elliptic to lanceolate, with acute to rounded base; pedicels 3–6 mm long. Subspecies *pilosula* differs in having the leaves slightly to markedly glaucous, round-ovate and distinctly subcordate to truncate at the base; pedicels 6–7 mm long; and the stature more shrubby, 1–2 m high. Subspecies *pilosula* is restricted to the interior side of the Santa Lucia Range divide, northwest of Santa Margarita and in the La Panza Range, while ssp. *pismoensis* is confined to the coastal side of the divide, chiefly in the Pismo sandstone country which forms the eastern sector of the San Luis Range, north of Pismo Beach. Introgression from *A. glauca* Lindley, another species from the interior side of the divide, could account for the main differentiating characters which distinguish the interior ssp. *pilosula* from the coastal ssp. *pismoensis*.

#### SUBSPECIES OF *ARCTOSTAPHYLOS HOOKERI*

*ARCTOSTAPHYLOS HOOKERI* D. Don ssp. *ravenii* P. V. Wells, ssp. nov. *A. ssp. hookeri* differt: frutex repens; folia circinata.

Holotype: on serpentinite, Presidio of San Francisco, San Francisco Co., California, *P. V. Wells 2767*, UC.

Low shrublet, creeping and the branchlets rooting on contact with the serpentine soil; flowers and fruits small as in ssp. *hookeri*, but smaller than in ssp. *franciscana*; leaves round or broadly elliptic, tetraploid ( $n = 26$ ). This subspecies is only one step from the extinction in nature which befell ssp. *franciscana*. It has been identified as ssp. *franciscana*, however, it has the smaller flowers and fruits of the diploid ( $n = 13$ ) ssp. *hookeri* combined with the creeping habit of ssp. *franciscana*. The small round leaves are distinctive.

Because of the resemblance of the tetraploid ( $n = 26$ ) *A. montana* Eastw. to ssp. *ravenii* in morphology, ecology, and chromosome number, it is now logical to treat *A. montana* as another serpentine adapted geographic subspecies of *A. hookeri*.

*ARCTOSTAPHYLOS HOOKERI* D. Don ssp. *montana* (Eastw.) P. V. Wells, comb. nov. *A. montana* Eastw., Proc. Calif. Acad. Sci. 1:83. 1897.

Subspecies *montana* differs from the other subspecies of *A. hookeri* in having densely canescent branchlets, and pedicels varying from straight to strongly recurved in fruit; it differs further from the other serpentine taxa, ssp. *ravenii* and ssp. *franciscana*, in being erect to low and mound-form, but not prostrate and creeping. Subspecies *montana* occupies a restricted geographical range to the north of the Golden Gate in Marin Co. where it is allopatric from other subspecies of *A. hookeri*. The canescent branchlets and recurved pedicels of ssp. *montana* suggest introgression from the sympatric *A. canescens* Eastw. (Stebbins and Major, 1965). Both occur on Mt. Tamalpais, but ssp. *montana* is restricted to serpentinite bedrock and *A. canescens* to outcrops of sandstone.

*ARCTOSTAPHYLOS HOOKERI* D. Don ssp. *hearthstiorum* (Hoover & Roof) P. V. Wells, comb. nov. *A. hearstiorum* Hoover & Roof, Four Seasons



2:2. 1966.

This diploid ( $n = 13$ ) subspecies occurs far to the south near the mouth of Arroyo de la Cruz in San Luis Obispo Co., but recombines some of the characters of the northern subspecies of *A. hookeri*. It differs from ssp. *hookeri* in having somewhat smaller leaves on shorter petioles, a smaller inflorescence, and a consistently creeping growth habit.

#### KEY TO THE SUBSPECIES OF ARCTOSTAPHYLOS HOOKERI

Fruit 4–5 mm in diameter; corolla 4–5 mm long.

Erect or forming low mounds, but not prostrate and creeping; leaves narrowly oblanceolate, lanceolate, elliptic or broadly round-elliptic; inflorescence with about 6–10 flowers; Monterey Peninsula north to the Santa Cruz Mountains, on siliceous substrata. . . . . *A. hookeri* ssp. *hookeri*

Prostrate and rooting along the creeping branchlets; occurring north or south of the above range.

Leaves broadly round-elliptic; inflorescence with about 6–10 flowers; Presidio of San Francisco, restricted to serpentinite bedrock.

*A. hookeri* ssp. *ravenii* Wells

Leaves elliptic to lanceolate; inflorescence with about 3–6 flowers; San Luis Obispo Co., restricted to sandy soil on bluffs near mouth of Arroyo de la Cruz. . . . . *A. hookeri* ssp. *heartsiorum* (Hoover & Roof) Wells

Fruit 6–8 mm in diameter; corolla 5–7 mm long.

Erect or forming low mounds, but not prostrate and creeping; leaves broadly elliptic; branchlets densely canescent; Marin Co., on serpentinite at Mt. Tamalpais, on granite at Inverness Ridge. *A. hookeri* ssp. *montana* (Eastw.) Wells

Prostrate and creeping; leaves narrowly elliptic or oblanceolate; branchlets puberulent, not canescent; San Francisco, now extinct in nature, formerly from Laurel Hill and Masonic Cemeteries, growing on serpentinite.

*A. hookeri* ssp. *franciscana* (Eastw.) Munz

#### SUBSPECIES OF ARCTOSTAPHYLOS MANZANITA

ARCTOSTAPHYLOS MANZANITA Parry ssp. *wieslanderii* P. V. Wells, ssp. nov. A ssp. *manzanita* differt: ramuli et petioli minute glandulosi: ramuli inflorescentiarum glandulosi; bractae glandulosae.

Holotype: black oak forest at 1,950 ft. elevation, Luck Creek, Shasta Co., California, *J. B. Griffin* 1267, UC.

Subspecies *wieslanderii* was known to A. E. Wieslander and members of the Vegetation Type Map Survey as “A. mx.”, and it is fitting to name it after a keen student of *Arctostaphylos*. This subspecies occupies an elevation belt above ssp. *manzanita*, with which it intergrades clinally around the northern perimeter of the Sacramento Valley.

It is now necessary to make a number of new combinations to establish a logical ordering of other taxa which closely resemble *A. manzanita*.

ARCTOSTAPHYLOS MANZANITA Parry ssp. *elegans* (Jeps.) P. V. Wells, comb. nov. *A. elegans* Jeps., *Erythra* 1:15. 1893; *A. manzanita* var. *elegans* (Jeps.) Benson, *Am. Jour. Bot.* 27:189. 1940.

This subspecies grows in an elevation zone above ssp. *manzanita* in the southern sector of the inner North Coast Range.

ARCTOSTAPHYLOS MANZANITA Parry ssp. *roofii* (Gankin) P. V. Wells, comb. nov. *A. roofii* Gankin, *Leaf. West. Bot.* 10:329. 1966.

The exerted stigma cited in the type description is a trait commonly found in *ssp. manzanita*. Gankin (1966) writes: "The striking similarity of this species to *A. manzanita* is a curious deception. The upper limit of *A. manzanita* in this region seems to be between 1,000 and 1,500 feet elevation. *Arctostaphylos elegans* appears to replace *A. manzanita* in the intervening areas, but only sparsely." As with *ssp. wieslanderi* and *ssp. elegans*, *ssp. roofii* occupies an elevation belt above *ssp. manzanita* occurring between 3,200 and 4,300 feet. However, it is more restricted in distribution than the other taxa, being confined to a small area in the North Coast Range of Glenn Co. The intrapopulational variability of the ovary indument from glandular-pubescent to pubescent to glabrous suggests the possibility of hybridity involving *A. glandulosa* Eastw., a burl-forming species with pubescent to glandular-pubescent ovaries, and *ssp. manzanita*, a non-sprouting subspecies with a glabrous ovary. The non-sprouting *ssp. elegans* may represent a different recombination of characters stemming from a similar cross. Chromosome counts of all three taxa indicate that they are tetraploid ( $n = 26$ ).

ARCTOSTAPHYLOS MANZANITA Parry *ssp. bakeri* (Eastw.) P. V. Wells, comb. nov. *A. bakeri* Eastw. Leaflet. West. Bot. 1:115, 1934; *A. stanfordiana* Parry *ssp. bakeri* (Eastw.) Adams, Jour. Elisha Mitchell Soc. 56:19, 1940.

The taxonomic position of this highly localized serpentine endemic of Sonoma Co. has long been uncertain. It has little in common with *A. stanfordiana* with which it was placed as a subspecies. The apparent reason for this disposition is that in terms of a key character, the glandulosity of branchlets and inflorescences, it is similar to *A. hispidula* Howell, a distinct species of serpentine habitat in Del Norte Co., which is closely related to *A. stanfordiana*. It is clear that with respect to nascent inflorescence, flowers, fruit, and chromosome number ( $n = 26$ ), the relationship of *ssp. bakeri* lies with *A. manzanita*. Populations of *ssp. manzanita* on serpentine bedrock in Sonoma Co., as at The Cedars, north of Cazadero, bear a striking resemblance to *ssp. bakeri* in stature, foliage, and compactness of the inflorescence, but lack the glandulosity. Subspecies *bakeri* differs from other subspecies of *A. manzanita* in combining glandular-hispid pubescence of branchlets, rachis, and bracts with somewhat smaller leaves and more compact inflorescence.

#### KEY TO THE SUBSPECIES OF ARCTOSTAPHYLOS MANZANITA

Basal burl lacking.

Branchlets, rachis, and bracts puberulent or glabrescent, but not glandular.

Ovary and fruit glabrous; branchlets and rachis puberulent.

Branches of nascent inflorescence elongate, slender, not clavate-thickened; widespread at lower elevations in the North Coast Ranges, around the head of the Sacramento Valley, and southward in the Sierra Nevada.

*A. manzanita ssp. manzanita*

Branches of nascent inflorescence short, clavate-thickened as in *A. pungens* HBK.; Contra Costa Co., endemic to Mt. Diablo and vicinity.

*A. manzanita ssp. laevigata* (Eastw.) Munz

Ovary and fruit with glandular, deciduous hairs; branchlets and rachis glabrescent; occupying a zone above ssp. *manzanita* in the North Coast Ranges.

*A. manzanita* ssp. *elegans* (Jeps.) Wells

Branchlets, rachis, and bracts minutely glandular-pubescent.

Inflorescence a large, ample, openly branched panicle; leaves broadly ovate; occupying a zone above ssp. *manzanita* around the head of the Sacramento Valley. . . . . *A. manzanita* ssp. *wieslanderi* Wells

Inflorescence smaller, more compact; leaves elliptic to ovate; Sonoma Co., endemic to serpentinite outcrops near Occidental.

*A. manzanita* ssp. *bakeri* (Eastw.) Wells

Basal burl present; occupying a zone above ssp. *manzanita* on the eastern slope of the North Coast Range in Glenn Co. *A. manzanita* ssp. *roofii* (Gankin) Wells

#### TAXONOMIC CONFUSION CONCERNING THE NON-SPROUTING SUBSPECIES OF ARCTOSTAPHYLOS PATULA

ARCTOSTAPHYLOS PATULA Greene ssp. *platyphylla* (Gray) P. V. Wells, comb. nov. *A. pungens* var. *platyphylla* Gray, Syn. Fl. N. Am. 2:28. 1878; *A. platyphylla* (Gray) Kuntze, Rev. Gen. 2:385. 1891; *A. obtusifolia* Piper, Bull. Torrey Club 26:642. 1902; *A. pinetorum* Rollins, Rhodora 39:462. 1937; *A. parryana* Lemmon var. *pinetorum* (Rollins) Wiesl. & Schreib., Madroño 5:46. 1939.

Away from the Sierra Nevada, Cascade Mountains, and North Coast Ranges, where the typical crown-sprouting form occurs, most populations of *A. patula* lack the burl at the base of the stem. Morphologically similar non-sprouting forms of the conifer/chaparral zone extend eastward to Utah and Colorado, northward into Oregon on the dry eastern side of the Cascade Mountains, and disjunctly southward in the San Gabriel, San Bernardino, and Santa Rosa mountains of southern California.

The geographically diverse, non-sprouting populations seem to resemble typical *A. patula* very closely, aside from absence of the burl, though careful examination of living populations may yield additional differentiae. However, at present, Gray's epithet, *platyphylla*, has priority for all non-sprouting populations of *A. patula*.

On the northeastern side of the Sacramento Valley, an erect form of *A. patula* ssp. *platyphylla* occupies a zone of elevation below that of the burl-forming ssp. *patula* and above that of the erect, non-sprouting *A. manzanita* ssp. *wieslanderi*. The zonation, which was called to my attention by James Griffin, is as follows: 1, *A. manzanita* ssp. *manzanita*, lowest zone, down to the valley floor; 2, *A. manzanita* ssp. *wieslanderi*; 3, *A. patula* ssp. *platyphylla*; and 4, *A. patula* ssp. *patula*, highest zone. Intermediates occur in populations of adjacent zones, but available information is insufficient to establish the existence of a cline along the entire gradient. Both *A. manzanita* ssp. *wieslanderi* and *A. patula* ssp. *platyphylla* may have originated in this area by hybridization of *A. manzanita* ssp. *manzanita* and *A. patula* ssp. *patula*, with subsequent backcrossing to one or the other parent, but it would be unwarranted to extend this speculation to account for loss of the burl in other popu-



lations of *A. patula*. It is likely that loss of the burl has occurred independently in the geographically disjunct populations of *A. patula* ssp. *platyphylla*.

#### SUBSPECIES OF *ARCTOSTAPHYLOS VISCIDA*

*ARCTOSTAPHYLOS VISCIDA* Parry ssp. *pulchella* (Howell) P. V. Wells, comb. nov. *A. pulchella* Howell, Fl. N. W. Am. 1:146. 1901.

Ranging through the North Coast Ranges, north to the Siskiyou Mountains of southern Oregon, ssp. *pulchella* differs from the glabrous-fruited ssp. *viscida* of the Sierra Nevada in having the ovary and fruit glandular-viscid.

*ARCTOSTAPHYLOS VISCIDA* Parry ssp. *mariposa* (Dudley) P. V. Wells, comb. nov. *A. mariposa* Dudley, Publ. Sierra Club 27:52. 1902.

This subspecies is more glandular than ssp. *pulchella*; not only the fruit, but also the branchlets, petioles, rachis, and bracts are densely glandular-pubescent. It occurs in the same elevation zone in the Sierra Nevada as ssp. *viscida*, but largely replaces the latter in the southern sector from Amador Co. south to Kern Co. Even at the southern extremity of the range of the species, variations to the glabrous condition of ssp. *viscida* occur, and very extensive intergradation between the glandular and non-glandular condition exists in the central Sierra Nevada, where ssp. *mariposa* merges with ssp. *viscida*. Also, as far north as southern Oregon, far from the range of ssp. *mariposa*, individuals with glandular-pubescent branchlets occur sporadically in glabrous-branched populations of ssp. *pulchella*.

#### KEY TO THE SUBSPECIES OF *ARCTOSTAPHYLOS VISCIDA*

Ovary and fruit glabrous, not viscid; branchlets and leaves usually glabrous; Sierra Nevada from Kern Co. north to Shasta Co. . . . *A. viscida* ssp. *viscida*

Ovary and fruit densely glandular-viscid.

Branchlets, leaves, and inflorescence densely glandular-pubescent; Sierra Nevada from Kern Co. north to Amador Co. *A. viscida* ssp. *mariposa* (Dudley) Wells

Branchlets and leaves mostly glabrous; inflorescence varying from glabrescent to sparingly glandular on rachis and bracts; North Coast Ranges from Napa Co. north to southern Oregon. . . *A. viscida* ssp. *pulchella* (Howell) Wells

#### INFRA-SPECIFIC TAXA OF *ARCTOSTAPHYLOS GLANDULOSA*

*ARCTOSTAPHYLOS GLANDULOSA* Eastw. ssp. *GLANDULOSA* f. *cushingiana* (Eastw.) P. V. Wells, comb. nov. *A. cushingiana* Eastw., Leaf. West. Bot. 1:175. 1933; *A. glandulosa* var. *cushingiana* (Eastw.) McMinn, Ill. Man. Calif. Shrubs 417. 1939.

The eglandular "*A. cushingiana*" and the glandular *A. glandulosa* occur as alternate intrapopulation forms (morphs) over much of the range of ssp. *glandulosa*. The parallel to the more localized polymorphism of *A. tomentosa* and its glandular form, f. *trichoclada*, is striking. Other morphological variants of the *A. glandulosa* complex have definite and largely allopatric geographic distributions and are recognized as subspecies.



ARCTOSTAPHYLOS GLANDULOSA Eastw. ssp. *howellii* (Eastw.) P. V. Wells, comb. nov. *A. howellii* Eastw., Leaf. West. Bot. 1:123. 1934; *A. glandulosa* var. *howellii* (Eastw.) McMinn, Ill. Man. Calif. Shrubs 417. 1939.

ARCTOSTAPHYLOS GLANDULOSA Eastw. ssp. *zacaensis* (Eastw.) P. V. Wells, comb. nov. *A. zacaensis* Eastw., Leaf. West. Bot. 1:79. 1933; *A. glandulosa* var. *zacaensis* (Eastw.) McMinn, Ill. Man. Calif. Shrubs 417. 1939.

ARCTOSTAPHYLOS GLANDULOSA Eastw. ssp. *mollis* (Adams) P. V. Wells, comb. nov. *A. glandulosa* var. *mollis* Adams, Jour. Elisha Mitchell Soc. 56:50. 1940.

ARCTOSTAPHYLOS GLANDULOSA Eastw. ssp. *crassifolia* (Jeps.) P. V. Wells, comb. nov. *A. glandulosa* var. *crassifolia* Jeps., Madroño 1:86. 1922; *A. tomentosa* var. *crassifolia* (Jeps.) Jeps., Man. Fl. Pl. Calif. 749. 1925.

#### A WIDELY DISJUNCT SUBSPECIES OF ARCTOSTAPHYLOS UVA-URSI IN GUATEMALA

ARCTOSTAPHYLOS CRATERICOLA (J. D. Smith) J. D. Smith is the name applied to a creeping manzanita found on the summits of lofty volcanos and other mountain peaks over 10,000 ft. high in Guatemala. It has been misunderstood, probably because it was originally described as a variety of *A. pungens* HBK., which is the only other species of *Arctostaphylos* ranging south through Mexico. It extends as far south as Oaxaca, Mexico. The many Mexican species of *Comarostaphylis* with synonyms in *Arctostaphylos* have added to the confusion.

An examination of a series of flowering and fruiting specimens of *A. cratericola* now available at US and NY shows that it has little in common with *A. pungens*, but is very similar to *A. uva-ursi*, differing mainly in the indument of the pedicels.

ARCTOSTAPHYLOS UVA-URSI (L.) Spreng. ssp. *cratericola* (J. D. Smith) P. V. Wells, comb. nov. *A. pungens* HBK. var. *cratericola* J. D. Smith, Bot. Gaz. 16:13. 1891; *A. cratericola* (J. D. Smith) J. D. Smith, Bot. Gaz. 55:437. 1913.

Prostrate, creeping and rooting along the branchlets, forming mats; branches with rough shreddy bark, the branchlets sparsely puberulent; leaves often resupinate on the prostrate branches, bifacial, the stomata restricted to the lower surface, spatulate or oblanceolate to elliptic, acute or apiculate to obtuse or rounded at the tip, cuneate at the base; petiole and leaf margins sparsely puberulent; inflorescence a dense, short simple cluster; rachis sparsely puberulent; bracts sparsely puberulent with glandular or eglandular hairs; pedicels varying from glandular-puberulent to glabrous; fruit red, shining, glabrous, oblate-spheroidal, the nutlets separable (previously, the fruit was unknown.)

Subspecies *cratericola* differs from ssp. *uva-ursi* in having pedicels varying from minutely glandular-puberulent to glabrous, instead of

consistently eglandular and usually glabrous; also the leaves vary from spatulate to oblanceolate or elliptic and from apiculate to obtuse at the tip, while ssp. *uva-ursi* shows leaf shape variation from spatulate to obovate, rarely elliptic, with the leaf tip consistently obtuse, rarely apiculate. The holotype of ssp. *cratericola* has markedly elliptic leaves, an unusual variation, and this may have been enough to obscure its relationship to *A. uva-ursi*.

Subspecies *cratericola* is known from the summits of three high mountain peaks in three different Departamentos of Guatemala: Volcán de Agua, Dept. Zacatepequez, at elevations from 8,000 to 12,300 ft. (holotype at 12,100 ft.); Volcán Zunil, Dept. Quezaltenango, from 9,850 to 12,500 ft.; and Sierra de los Cuchumatanes, Dept. Huehuetenango, from 10,800 to 11,500 ft., on limestone. These are indeed remarkably disjunct occurrences of *A. uva-ursi*, which is unknown from all of Mexico, the southernmost stations being in New Mexico. It is suggestive to note that a collection from Hermit's Peak, San Miguel Co., N. M., Wells 42962, KANU, has the glandular branchlets and bracts of *A. uva-ursi* var. *adenotricha* Fern. & Macbr.; also the leaves are apiculate and oblanceolate, but the pedicels are glabrous.

#### A CYTOTAXONOMIC SURVEY OF ARCTOSTAPHYLOS

Chromosome counts have been published for only a few species and all have the base number 13. This number has been observed in other genera of Ericaceae, including the closely related *Arctous* and *Xylococcus*. During the year 1966–1967, I was able to fix meiotic material of about 58 taxa, nearly all of which yielded good cytological preparations. The data are summarized in Table I.

Although the size of the genus prohibited a series of counts for each taxonomic unit, enough information has been gleaned to show consistent patterns, which have predictive value. In brief, two levels of ploidy exist:  $n = 13$  and  $n = 26$ . A leading generalization is that the many races of the leafy-bracted burl-forming species, *A. tomentosa* and *A. glandulosa*, are tetraploid ( $n = 26$ ); they are confined to the coastal half of California, chiefly within the fog belt. On morphological and ecological grounds they appear to be relatively less specialized than the non-sprouting species with fire-stimulated germination, which occupy a wider range of habitats, and have a vastly greater geographic distribution. The fact that two burl-forming species with reduced bracts are diploid ( $n = 13$ ), namely *A. patula* and *A. rudis*, shows that tetraploidy is not constantly associated with burl-formation, although this may be a predisposing condition. The much greater life-span of the burl-formers under the conditions of frequent fire prevalent in chaparral would also tend to favor the preservation of individuals having undergone a change in chromosome number, thus affording a longer time period in which selection could operate on their progeny.

TABLE I. CHROMOSOME NUMBERS IN ARCTOSTAPHYLOS. RPBG = PLANTS PROPAGATED IN THE REGIONAL PARKS BOTANIC GARDEN, BERKELEY. UCBG = FROM PLANTS PROPAGATED IN THE UNIVERSITY OF CALIFORNIA BOTANICAL GARDEN. PREPARED SLIDES, CAMERA LUCIDA DRAWINGS, AND VOUCHER SPECIMENS ARE AVAILABLE (KANU).

- A. andersonii* Gray. **n** = 13. Santa Cruz Co., Big Basin. *Wells* 25672.  
*A. auriculata* Eastw. **n** = 13. Contra Costa Co., Mt. Diablo, RPBG. *Wells* 2867.  
*A. canescens* Eastw. **n** = 13. Marin Co., Mt. Tamalpais. *Wells* 11566.  
*A. columbiana* Piper. **n** = 13. Del Norte Co., Darlingtonia *Wells* 21267; UCBG. *Wells* 223671.  
*A. confertiflora* Eastw. **n** = 13. Santa Barbara Co., Santa Rosa I., UCBG. *Wells* 223672.  
*A. cruzensis* Roof. **n** = 13. San Luis Obispo Co., Los Osos Valley. *Wells* 1867.  
*A. densiflora* Baker. **n** = 13. Sonoma Co., Vine Hill, UCBG. *Wells* s.n.  
*A. edmundsii* Howell. **n** = 13. Monterey Co., Little Sur River. *Wells* 919661.  
*A. edmundsii* Howell  $\times$  *A. tomentosa* ssp. *rosei* (Eastw.) Wells. **n** = 13. Monterey Co., Garrapata Creek. *Wells* 919662.  
*A. glandulosa* Eastw. **n** = 26. Marin Co., Mt. Tamalpais *Wells* 24671; *Wells* 24672.  
*A. glandulosa* f. *cushingiana* (Eastw.) Wells. **n** = 26. Mendocino Co., Trinity Grade., UCBG. *Wells* 419671; Marin Co., Mt. Tamalpais. *Wells* 24673; *Wells* 24674; San Luis Obispo Co., La Panza Range, UCBG. *Wells* 419672.  
*A. glandulosa* ssp. *zacaensis* (Eastw.) Wells. **n** = 26. Santa Barbara Co., Figueroa Mt. *Wells* 43067.  
*A. glauca* Lindley. **n** = 13. San Luis Obispo Co., Pozo, UCBG. *Niehaus* 271; San Diego Co., Dulzura, UCBG. *Niehaus* 272.  
*A. glutinosa* Schreib. **n** = 13. Santa Cruz Co., Eagle Rock, RPBG. *Roof* s.n.  
*A. hookeri* D. Don ssp. *hookeri*. **n** = 13. Monterey Co., Monterey Bay, UCBG. *Wells* 84671.  
*A. hookeri* ssp. *hearstiorum* (Hoover & Roof) Wells. **n** = 13. San Luis Obispo Co., Arroyo de la Cruz, RPBG. *Roof* s.n.  
*A. hookeri* ssp. *montana* (Eastw.) Wells. **n** = 26. Marin Co., Mt. Tamalpais. *Wells* 42467; UCBG. *Wells* s.n.  
*A. hookeri* ssp. *ravenii* Wells. **n** = 26. San Francisco Co., San Francisco, Presidio. *Wells* 2767.  
*A. imbricata* Eastw. **n** = 13. San Mateo Co., San Bruno Mt., UCBG. *Wells* 223673.  
*A. insularis* Greene f. *insularis*. **n** = 13. Santa Barbara Co., Santa Cruz I., UCBG. *Wells* 124671.  
*A. insularis* Greene f. *pubescens* (Eastw.) P. V. Wells, comb. nov. *A. insularis* Greene var. *pubescens* Eastw. Leaf. West. Bot. 1:62. 1933. **n** = 13. Santa Barbara Co., Santa Cruz I., Christie's. *Niehaus* 484. This form with glandular-pubescent branchlets and tomentose ovary is the prevalent one on the island. The glabrous nominate form occurs sporadically as an intra-populational morph, chiefly on the interior ridges. Introgression of genes from the sympatric, glandular species, *A. tomentosa* ssp. *subcordata* (Eastw.) Wells, is a suspected cause of the polymorphism.  
*A. luciana* Wells. **n** = 13. San Luis Obispo Co., Santa Lucia Mts. *Wells* 1767; UCBG. *Wells* 223674.  
*A. manzanita* Parry ssp. *manzanita*. **n** = 26. Lake Co., N. of Mt. St. Helena, RPBG. *Roof*, s.n.  
*A. manzanita* ssp. *bakeri* (Eastw.) Wells. **n** = 26. Sonoma Co., Occidental, UCBG. *Wells* 12567.  
*A. manzanita* ssp. *elegans* (Jeps.) Wells. **n** = 26. Lake Co., Lower Lake, UCBG. *Niehaus* 255.  
*A. mewukka* Merriam. **n** = 26. El Dorado Co., Peavine Ridge. *Wells* 326673; *Wells* 326674; *Wells* 326675.



TABLE I. (Continued).

- A. morroensis* Wiesl. & Schreib. **n** = 13. San Luis Obispo Co., Morro Bay. *Wells* 22667; Hazard Canyon, UCBG. *Wells* s.n.
- A. nevadensis* Gray. **n** = 26. Siskiyou Co., Mt. Shasta. *Wells* 7167.
- A. nissenana* Merriam. **n** = 13. El Dorado Co., Diamond Springs, UCBG. *Wells* 124672.
- A. nummularia* Gray ssp. *nummularia*. **n** = 13. Mendocino Co., Mendocino Plains, UCBG. *Wells* 84673.
- A. nummularia* Gray ssp. *sensitiva* (Jeps.) P. V. Wells, comb. nov. *A. sensitiva* Jeps. Madroño 1:85. 1922. *A. nummularia* var. *sensitiva* (Jeps.) McMinn. Ill. Man. Calif. Shrubs 389. 1939. **n** = 13. Marin Co., Mt. Tamalpais. *Wells* 51367. Subspecies *nummularia* differs from ssp. *sensitiva* chiefly in growth habit. However, ssp. *nummularia* is quite variable in growth habit, ranging from prostrate to almost as erect as ssp. *sensitiva*. Hybridization with the prostrate *A. uva-ursi* (L.) Spreng. is evident near the coast, and probably accounts for the divergence of the maritime ssp. *nummularia* from the montane ssp. *sensitiva*.
- A. obispoensis* Eastw. **n** = 13. San Luis Obispo Co., Santa Lucia Mts., RPBG. *Roof* s.n.
- A. otayensis* Wiesl. & Schreib. **n** = 13. San Diego Co., Otay Mt., RPBG. *Wells* 2667.
- A. pajaroensis* Adams **n** = 13. Monterey Co., Pajaro Hills. *Wells* 919663.
- A. pajaroensis* Adams  $\times$  *A. tomentosa* (Pursh) Lindley. **n** = 13. Monterey Co., Pajaro Hills, RPBG. *Wells* 92566.
- A. pallida* Eastw. **n** = 13. Alameda Co., Huckleberry Ridge. *Wells* 1124661; Manzanita Drive. *Wells* 1124662.
- A. parryana* Lemmon. **n** = 26. Kern Co., Mt. Abel. *Wells* 6767; Ventura Co., Mt. Pinos, RPBG. *Roof* s.n.
- A. patula* Greene. **n** = 13. El Dorado Co., Peavine Ridge. *Wells* 326672.
- A. patula* Greene  $\times$  *A. viscida* Parry. **n** = 13. El Dorado Co., Peavine Ridge. *Wells* 326671.
- A. pechoensis* Dudley. **n** = 13. San Luis Obispo Co., See Canyon. *Wells* 1023662.
- A. pilosula* ssp. *pismoensis* Wells. **n** = 13. San Luis Obispo Co., Edna, UCBG. *Wells* 12567.
- A. pumila* Nutt. **n** = 13. Monterey Co., Fort Ord, UCBG. *Wells* 84672.
- A. purissima* Wells. **n** = 13. Santa Barbara Co., Lompoc, UCBG. *Wells* 223673.
- A. refugioensis* Gankin. **n** = 13. Santa Barbara Co., Refugio Pass. *Wells* 5667.
- A. regismontana* Eastw. **n** = 13. San Mateo Co., King's Mt., RPBG. *Roof* s.n.
- A. \times repens* (Howell) P. V. Wells, comb. nov. *A. cushingiana* f. *repens* Howell, Leaf. West. Bot. 4:161. 1945. **n** = 13. Marin Co., Mt. Vision, UCBG. *Wells* 41967. Howell's name is based on hybrid individuals produced in a small area on Inverness Ridge where *A. uva-ursi* (L.) Spreng., *A. virgata* Eastw. and *A. glandulosa* Eastw. are sympatric.
- A. rudis* Jeps. & Wiesl. **n** = 13. San Luis Obispo Co., Nipomo Mesa. *Wells* 1023661.
- A. stanfordiana* Parry. **n** = 13. North Coast Range, RPBG. *Wells* 223674.
- A. tomentosa* (Pursh) Lindley ssp. *tomentosa*. **n** = 26. Monterey Co., Monterey Bay dunes, RPBG. *Roof* s.n.; San Luis Obispo Co., Arroyo de la Cruz. *Wells* 42667; Los Osos Valley. *Wells* 1867.
- A. tomentosa* ssp. *crustacea* (Eastw.) Wells. **n** = 26. Contra Costa Co., Moraga Ridge UCBG. *Wells* 84674.
- A. tomentosa* ssp. *insulicola* Wells. **n** = 26. Santa Barbara Co., Santa Cruz I., Pelican Bay. *Wells* 5467; Laguna Canyon. *Wells* 53671.
- A. tomentosa* ssp. *rosei* (Eastw.) Wells. **n** = 26. Monterey Co., Bixby Cr., UCBG. *Wells* 84675.
- A. tomentosa* ssp. *subcordata* (Eastw.) Wells. **n** = 26. Santa Barbara Co., Santa Cruz I., China Harbor. *Wells* 5267; Christie's. *Wells* 53672.



TABLE I. (Continued).

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- A. tomentosa* ssp. *tomentosiformis* (Adams) Wells. **n** = 26. Santa Cruz Co., Felton. Wells 25671.
- A. virgata* Eastw. **n** = 13. Marin Co., Mt. Tamalpais. Wells 2467.
- A. viridissima* (Eastw.) McMinn. **n** = 13. Santa Barbara Co., Santa Cruz I., China Harbor. Niehaus 501.
- A. viscida* Parry ssp. *viscida*. **n** = 13. Amador Co., Ione, UCBG. Wells 84677.
- A. viscida* ssp. *mariposa* (Dudley) Wells. **n** = 13. Sierra Nevada, RPBG. Roof s.n.
- 

For some tetraploids, there is morphological evidence of hybridity involving existing diploid species, and the distributional and ecological facts provide strong support for their origin through amphidiploidy. One example is the tetraploid *Arctostaphylos newukka* Merriam. It occurs as sporadic colonies which are restricted to a zone of elevation where the distributions of two diploid species, *A. patula* Greene and *A. viscida* Parry, overlap in the Sierra Nevada. A character analysis employing 50 morphological traits shows that *A. newukka* combines the characters of *A. patula* and *A. viscida* in the following way: characters shared with *A. viscida* exclusively, 12; characters shared with *A. patula* exclusively, 7; characters shared with both *A. viscida* and *A. patula*, 30; transgressive characters, 1 (fruit size). The morphology indicates hybridization of *A. viscida* with *A. patula*, followed by stabilization of the *A. newukka* character combination; the cytology suggests that stabilization was achieved through amphidiploidy.

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## NOTES AND NEWS

NOTES ON *MADIA SATIVA* AND RELATED SPECIES.—*Madia capitata* Nutt., *M. sativa* Molina and *M. gracilis* (Smith) Keck are closely related and often difficult to distinguish. They tend to intergrade and diagnoses in current manuals lack clearcut characteristics by which to delimit the species. In 1965, at the suggestion of John Thomas Howell, I checked the odors of these plants in the field in the Santa Cruz Mountains, central California. Odor is one of the distinguishing characteristics given, although not a very satisfactory one, for two reasons: 1, it applies only to fresh material, and 2, there are no names for odors as such. Names for odors are always given as similar to other, supposedly universally known ones, or in terms of subjective reaction, which necessarily varies from person to person.

The first discovery of this investigation was rather surprising. The troublesome forms intermediate between *M. sativa* and *M. gracilis* smelled different from either of these species, being basically similar but lacking both the spicy fragrance of *gracilis* and the heavy unpleasant odor of *sativa*. These considerations led me to speculate that another distinct entity probably was involved and, with the encouragement of Rimo Bacigalupi, I attempted a diagnosis of this "new" variety (as I would have evaluated it) under an appropriately descriptive epithet, based on *Hesse 3318* (JEPS). This analysis proved inconclusive because morphological characters proved to be varyingly intermediate, with the single exception of the achenes, which were found to be consistently small (only a little longer than those of *gracilis*) and slender; in shape most nearly like those of *capitata*. Howell had further commented that probably sometime someone would conclude that all these species were in reality one variable species. If so, the earliest name, *M. sativa*, should be used. There is much to be said in favor of this idea. For instance, my specimens, 3315 (CAS), 3317, 3237, 3316, 3318, 3234, 3321, 3319, and 3232 (all JEPS) form an almost continuous series, morphologically, from *gracilis* to *capitata*. Moreover, further investigation showed that even the odors of this complex graded into one another, i.e., all the intermediate forms did not smell exactly the same but tended toward one or another of the species heretofore recognized. It is my hope that these investigations will be of help to those who may wish to delve more deeply into the *Madia sativa* complex.—V. F. HESSE, Boulder Creek, California.

CHROMOSOME COUNTS IN SECTION SIMIOLUS OF THE  
GENUS MIMULUS (SCROPHULARIACEAE). VII. NEW  
NUMBERS FOR *M. GUTTATUS*, *M. CUPREUS*,  
AND *M. TILINGII*

R. K. VICKERY, JR., K. W. CROOK, D. W. LINDSAY, M. M. MIA,  
and W. TAI

The purpose of this report is to gather together and summarize the chromosome numbers found in *M. guttatus* DC. in the course of a series of experimental evolution studies (Vickery, 1966; Vickery and Lindsay, 1961; 1966; Vickery and Mia, 1966; and unpublished) and to present new numbers for *M. cupreus* Dombroin and *M. tilingii* Regel. Our findings, particularly those concerning irregular chromosome segregation in *M. guttatus*, significantly broaden the cytogenetic concept of each of these three species.

The cytological techniques employed were essentially the same as those previously used (Mia, Mukherjee, and Vickery, 1964) except that the first half of the slides were made permanent according to the method of Beeks (1955). His technique proved satisfactory, but was not superior to our usual method. Representative chromosome configurations were recorded either photographically or by drawings made with the aid of a camera lucida. Counts for a culture of a population or for a hybrid were based on a study of an average of over thirty cells representing an average of three plants for each. Vouchers of each culture have been deposited in the University of Utah herbarium. Many of the counts here reported are included in the theses of the junior authors submitted to the University of Utah in partial fulfillment of the requirements for the Master's (K. W. Crook) and Ph.D. degrees. The work was supported in part by grants G 10603, GB 562, and GB 2996 from the National Science Foundation and in part by grants from the University of Utah Research Fund.

The normal  $n=14$  chromosome number of *Mimulus guttatus* (Mia, Mukherjee, and Vickery, 1964) was confirmed for 20 additional populations (table 1). Nine of these populations (table 2), all from northern Utah, exhibited irregular chromosome segregations in meiosis like the two cases previously reported for populations from the Sierra Nevada of California (Mukherjee and Vickery, 1959). Irregular segregations were detected also in culture 5839 ( $n=14$ ) from the Spruces picnic area in the Big Cottonwood Canyon of northern Utah. The aberrant microsporocytes produced by the irregular segregations were functional, at least occasionally, and hence significant. One aneuploid parental plant and one  $F_1$  hybrid lacking a chromosome were detected.

In all ten cultures the irregular segregations typically produced a few microsporocytes with either  $n=13$  or  $n=15$  chromosomes instead of the normal  $n=14$  number. In two of the populations the irregularities were more pronounced. Culture 6649 of the Brighton population was



TABLE 1. CHROMOSOME COUNTS IN *MIMULUS*, SECTION *SIMIOLUS*

*M. cupreus* Dombrain.  $n=31$ : Chile, Nuble. Termas de Chillan, 7,000 ft, *Moore* 420, 6318<sup>1</sup>.  $n=32$ : Cultivated under the names Bee Dazzler and *M. beeslanus* Bergm. in the Botanic Garden, Uppsala, Sweden, 5684.

*M. guttatus* DC.  $n=14$ : Utah. Cache Co. Logan River, 5,050 ft, 6176<sup>2</sup> and 8,500 ft, 6173. Juab Co. Thomas Creek, 4,775 ft, 6154; 7,200 ft, 6172; and 9,000 ft, 6170. Salt Lake Co. Brighton, 8,760 ft, 6649 and 9,250 ft, 7102; East Millcreek, 7,680 ft, 6648. Tooele Co. South Willow Creek, 5,800 ft, 6158 and 8,000 ft, 6178. Utah Co. Utah Lake, 4,500 ft, 6145; Provo River, 5,100 ft, 6164; 5,800 ft, 6167; 7,600 ft, 6168; Payson Creek, 7,800 ft, 6658 and 7,800 ft, 6661. Calif. Mono Co. Mt. Dana, 8,000 ft, 6667. New Mexico. Catron Co. Aragon, 6,800 ft, 6611. Colo. Grand Co. Grand Lake, 9,560 ft, 7139.  $n=15$ : Utah. Cache Co. Providence, 4,500 ft, 6177.  $n=16$ : Colo. Grand Co. Grand Lake, 9,500 ft, 7141. Mexico, Durango. Santiago Papasquiaro, 8,400 ft, *Wiens* 3,521, 6646.  $n=28$ : New Mexico. Catron Co. Reserve, 5,770 ft, 6613; Grant Co. Gila River, 4,400 ft, 6615; Rio Arriba Co. Rio Chama, 7,500 ft, 6622. Colo. La Plata Co. Los Pinos River, 6,750 ft, 6627. Alaska. Admiralty Island. Gambier Bay, sea level to 1,000 ft, *Miller*, Aug. 1958, 6152. Mexico, Durango. Santiago Papasquiaro, 8,400 ft, *Wiens* 3,522, 6647.

*M. luteus* L.  $n=31$ : Chile, Nuble. Las Cabras, 5,000 ft, *Peña*, Feb. 6, 1963, 6685.

*M. tilingii* Regel.  $n=28$ : Calif. El Dorado Co. US 89, 7,200 ft, 6664.

<sup>1</sup> Author's culture number.

<sup>2</sup> Populations for which no collector is given were collected by Vickery and/or co-workers and any that were distributed included the indicated culture number.

observed to have one microsporocyte with  $n=12$  chromosomes as well as one with  $n=15$  and 30 with the normal  $n=14$ . Culture 6648 from the Big Water Gulch population carried the degree of irregularity further yet. One cell was observed to have  $n=10$  chromosomes in addition to one with  $n=15$  and 10 with  $n=14$ . The highest percentage of irregularity observed was 60%. This amount was shown by a population from the Utah Valley (table 2). However, the general average was much lower. Irregular chromosome segregation may be a far more widespread phenomenon in *M. guttatus* than we had supposed because it often occurs at such low frequencies (table 2) that we easily might have missed it previously.

In order to provide additional information to help explain the nature of the irregular chromosome segregations, each of a series of cultures of northern Utah populations including some that exhibited irregular segregations and some that did not were crossed to a culture (5052) of a normal California population and to a culture (6082) of a Utah population that displayed irregular segregation (table 2). Examination of the results suggests that an explanation based on simple gene control is unlikely. Observation of occasional univalents in the  $F_1$  hybrids, indicates that lack of homology may be a valid explanation for some of the observed irregular segregations in the hybrids, particularly those from geographically isolated parents. A few, but widely distributed, observations of chromatin bridges in anaphase coupled with pervasive regular bivalent pairing suggests to us the occurrence of different inversions in



TABLE 2. SUMMARY OF CHROMOSOME COUNTS OBSERVED IN VARIOUS STAGES OF MICROSPOROGENESIS FROM THE PARENTAL CULTURES AND THE INTER-CULTURE  $F_1$  HYBRIDS OF NORTHERN UTAH *MIMULUS GUTTATUS* POPULATIONS. See Table 1 for origins of these cultures or for references for those not listed in this report.

	Parental populations:				F <sub>1</sub> hybrids with 5052:				F <sub>1</sub> hybrids with 6082:			
	n=13	n=14	n=15	% ir.	n=13	n=14	n=15	% ir.	n=13	n=14	n=15	% ir.
Controls												
5052	0	17	0	0.0	----	----	----	-----	----	----	----	-----
6082	2	8	0	20.0	0	87	0	0.0	----	----	----	-----
Populations												
5834	0	10	0	0.0	0	9	1	10.0	1	18	2	14.3
5835	0	13	0	0.0	0	35	0	0.0	1	27	1	6.9
5839	3	28	0	9.7	0	35	0	0.0	1	34	0	2.8
6090	2	12	0	14.3	1	18	0	5.3	0	12	0	0.0
6127	0	54	0	0.0	0	25	1	3.8	0	21	0	0.0
6145	26	25	12	60.3	0	11	0	0.0	(failed to flower)			
6154	0	33	0	0.0	3	97	4	6.7	0	10	0	0.0
6158	2	34	1	8.1	0	24	1	4.0	1	34	4	12.8
6164	0	27	0	0.0	0	6	0	0.0	1	32	0	3.3
6167	1	15	0	6.2	0	10	1	9.1	5	26	2	21.2
6168	0	21	0	0.0	(failed to flower)				0	25	0	0.0
6170	1	61	0	1.6	0	15	0	0.0	1	10	2	23.1
6172	0	29	0	0.0	2	60	0	3.2	1	45	0	2.2
6173	0	21	0	0.0	1	70	0	1.4	0	24	0	0.0
6175	1	25	0	3.8	3	34	1	10.5	0	81	0	0.0
6176	0	28	0	0.0	0	7	0	0.0	0	46	0	0.0
6178	0	16	0	0.0	0	50	0	0.0	2	25	0	7.4

the various populations. They would contribute to the explanation of the irregular segregations also. Further study is needed, because knowledge of the real causes of the observed irregular chromosome segregations is fundamental to our understanding of the evolutionary mechanisms operating within *M. guttatus* and particularly of the observed aneuploid changes in the species.

The first example of aneuploidy at the  $n=15$  level in *M. guttatus* was found in a population (culture 6177) from the Cache Valley, Utah (table 1). The population is relatively uniform morphologically although its leaves are rounder and its calyces are blunter than is usual in *M. guttatus*. These traits suggest to us that this population may be showing the residual effects of previous introgression from *M. glabratus* var. *utahensis* Pennell. The latter species generally has  $n=15$  chromosomes as well as the traits mentioned. Presently it occurs to the south and west of the Cache Valley throughout the Great Basin and central Mexico, but it may have spread into the Cache Valley some 7,500 to 4,000 years ago during the altithermal period (Antevs, 1955) when other more southerly distributed species such as *Quercus turbinella* Greene apparently migrated hundreds of miles northward in Utah (Cottam, Tucker, and Drobnick, 1955). Hybridization of *M. guttatus* with *M. glabratus* could have occurred at that time. Subsequently, with the return of cooler temperatures, the most northern *M. glabratus* populations such as the

putative ones in the Cache Valley, would be expected to have died out. Natural selection, in turn, would be expected to have favored the best adapted members of the remaining hybrid swarms and in time to have produced the present populations.

The  $F_1$  hybrids of this Cache Valley aneuploid population (culture 6177) exhibited irregular chromosome segregation even though no irregularities were observed in the 28 cells studied of the parental culture itself. Its  $F_1$  hybrids with culture 5052 revealed one microsporocyte with  $n=12$  chromosomes, fourteen with  $n=13$ , twenty-one with  $n=14$ , twelve with  $n=15$ , and one with  $n=16$ . In contrast, its  $F_1$  hybrids with culture 6082 exhibited two microsporocytes with  $n=13$  chromosomes and fifty-five with  $n=14$ . Figured on the assumption that a regular segregation of chromosomes of the  $F_1$  hybrids of this culture ( $n=15$ ) with each of the controls (both are  $n=14$ ) should have yielded  $n=14$  and  $n=15$  microsporocytes in equal numbers, the irregular segregation observed occurred at a rate of approximately 50%. The results are a poor fit for this assumption. Perhaps a better hypothesis would be that the fifteenth chromosome of culture 6177 is a special type of B chromosome that is regularly lost in the culture's  $F_1$  hybrids. Then the culture's  $F_1$  hybrids would be expected to have  $n=14$  chromosomes which occurs in the cross  $6082 \times 6177$  in over 96% of the cells examined. In the cross  $5052 \times 6177$  there are many 15 to 13 irregular segregations. However, this type of irregularity clearly suggests that  $n=14$  is actually the number rather than  $n=15$ . The behavior of the chromosomes of the  $F_1$  hybrids of aneuploid *M. platycalyx* Pennell (culture 5752,  $n=15$ ) could be interpreted in the same way (Mukherjee and Vickery, 1962). However, until clearer proof of the accessory nature of culture 6177's fifteenth chromosome is obtained it seems best to consider the population as a straight  $n=15$  aneuploid, although noting the apparent B-chromosome-like loss of the fifteenth chromosome in the hybrids of the culture.

Aneuploidy at the  $n=16$  level occurs in two distinctly different races of *M. guttatus* (fig. 1). The first race, as represented by culture 6646, consists of a small-flowered, small-leaved type of plant from near the crest of the Sierra Madre Occidental west of Durango, Mexico. Our previous  $n=16$  counts are for closely similar populations from the same general area (Mia, Mukherjee, and Vickery, 1964). The results of hybridization experiments now in progress may warrant segregating this race from *M. guttatus* as a new species. The other  $n=16$  count is for an unusual race, represented by culture 7141, that reproduces by axillary propagules. It has been collected from several localities in the vicinity of Grand Lake, Colorado by Mrs. Margaret Douglas to whom we are indebted for the material studied.

Six different *M. guttatus* populations were found to be tetraploid ( $n=28$ ). The five from northern Mexico, New Mexico, and southern Colorado appear to be autotetraploids. However, their allopolyploid origin

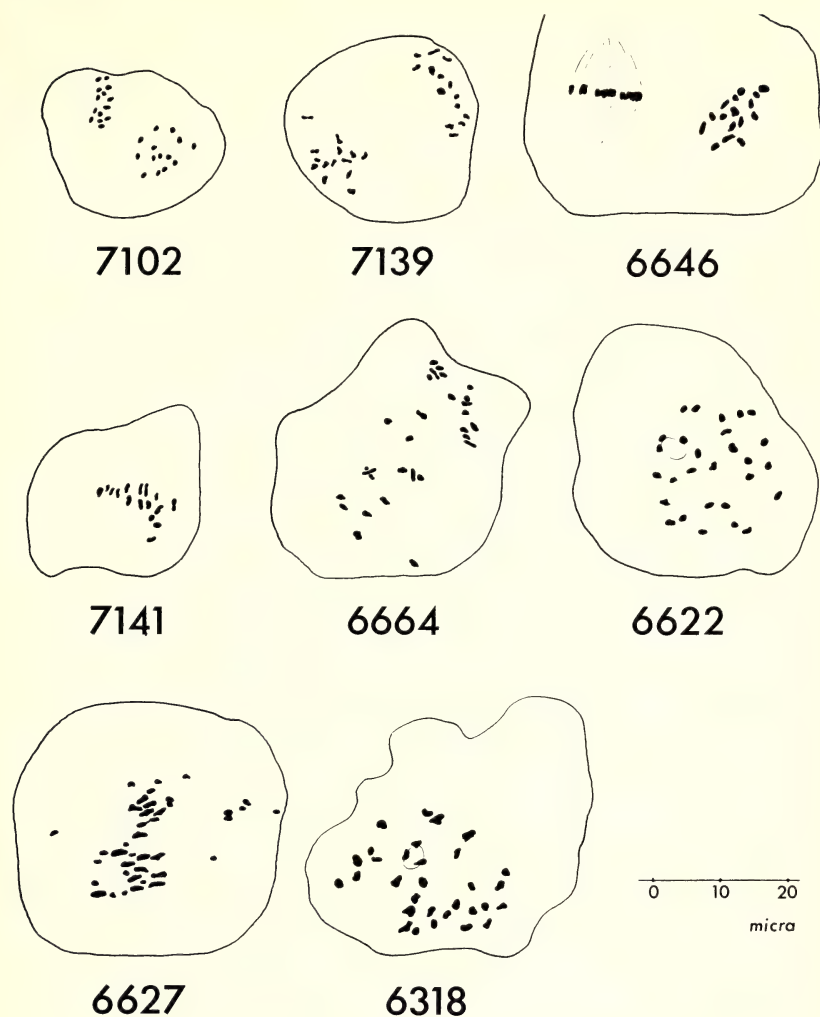


FIG. 1. Meiotic chromosomes of *Mimulus*. Cultures 7102 and 7139 are typical  $n=14$ , *M. guttatus* in anaphase II and anaphase I, respectively; cultures 6646 and 7141 are  $n=16$  aneuploid races of *M. guttatus* in metaphase II and metaphase I, respectively; culture 6664 is tetraploid,  $n=28$  *M. tilingii* in metaphase I; cultures 6622 and 6627 are tetraploid,  $n=28$  *M. guttatus* in diakinesis and metaphase I, respectively (note, the regular pairing in the former and the presence of  $19_{II}$  and  $18_I$  associations in the latter), and culture 6318 is aneuploid,  $n=31$  *M. cupreus* in diakinesis. The camera lucida drawings were at an original magnification of  $\times 2,850$ , reduced to approximately  $\times 950$  in reproduction.

from different *M. guttatus* populations cannot be excluded, particularly in view of a high frequency of univalents in the Colorado population, culture 6627 (fig. 1). Morphologically these populations are indistinguishable from the diploids of their area as in the previous, single ex-

ample of tetraploidy (fig. 2) in *M. guttatus*, the population (6152) from the Verde Valley in central Arizona (Mia, Mukherjee, and Vickery, 1964).

The sixth  $n=28$  population is from Admiralty Island towards the other end of the range of *M. guttatus*. This population is typical of a race that is widespread in coastal Alaska and the Aleutian Islands according to the herbarium specimens in the British Museum. A photograph of the De Candolle herbarium specimen of *M. guttatus* suggests to us that De Candolle's type for the species may belong to this race. Plants of a culture (6250) of this population cross readily with plants of culture 5052 from Mt. Diablo, California, our standard test population. Observations of microsporogenesis in the resulting vigorous, but sterile  $F_1$  hybrids revealed 30 cells with 14 II and 14 I chromosome associations. Fifteen cells exhibited slightly less pairing down to one with a low of 5 II and 32 I associations. In view of the numerous quadrivalent chromosome associations observed in the culture itself (fig. 2), it is not clear whether autosynesis of the chromosomes of culture 6250 was being detected or whether the pairing of the basic genome, thought to be present throughout all species of section *Simiolus* (Mukherjee and Vickery, 1962), was being observed. Plants of culture 6250 will not hybridize with those of the tetraploid population (culture 6152) from the Verde Valley which suggests that the former hypothesis is more likely. Clearly, if the Alaskan race is an autotetraploid it comes from a rather different race than the other autotetraploids. Possibly it is derived from the coastal ecotype. However, the short height and relatively large flowers of the plants may reflect an allopolyploid origin for this race from closely related forms (whose chromosomes pair) involving perhaps some combination of the inland race, the coastal ecotype, or alpine *M. tilingii* or one of its relatives.

As a result of these investigations of *M. guttatus* we find that aneuploidy is part of the cytogenetic picture of the species as is irregular chromosome segregation in meiosis. The latter phenomenon is now known to occur in 12 populations and probably is more widespread yet. Tetraploidy also is more common than we had previously thought. Seven tetraploid populations now have been found among the 76 populations of *M. guttatus* analyzed to date (Vickery, 1955; Mukherjee, Wiens and Vickery, 1957; Mukherjee and Vickery, 1959 and 1960; Mia, Mukherjee, and Vickery, 1964; and table 1).

*Mimulus cupreus* Dombrain was found to have  $n=31$  and  $n=32$  populations (table 1). These results are in line with earlier crossing studies (unpublished) which showed *M. cupreus* to cross readily in most cases with *M. luteus* L.,  $n=30$ , 31, 32, and *M. tigrinus* hort.,  $n=30$ , 32 (Mukherjee and Vickery, 1959, 1960; Mia, Mukherjee, and Vickery, 1964; and table 1). The latter two species cross successfully with each other in some combinations, but not in others.

A single tetraploid population of *M. tilingii* from the Sierra Nevada





FIG. 2. Chromosome configurations of two tetraploid,  $n=28$ , races of *M. guttatus*. Culture 6152 is from the Verde Valley, Arizona population and culture 6250 is from the Admiralty Island, Alaska population. Both cells are in metaphase I. Note how frequently the bivalents are paired in loose quadrivalent associations. Drawn with the aid of a camera lucida at an original magnification of  $\times 1800$  reduced to  $\times 900$  in reproduction.

of California was found. This discovery is of interest in explaining the origin of *M. tilingii* var. *corallinus* with its  $n=24$  chromosomes (Mukherjee and Vickery, 1959). Perhaps the latter entity arose from a cross between diploid and tetraploid forms of *M. tilingii* or between diploid *M. guttatus* (no tetraploids are known in the area) and tetraploid *M. tilingii*. The more *tilingii*-like than *guttatus*-like morphology of the variety suggests that the former hypothesis is more probable.

Our cytological findings suggests to us the possible presence in section *Simiolus* of *parallel chromosome races* in related species like the parallel series of morphologic races found by Vavilov (1923) in cereals and other plants. For example, *M. tilingii* has  $n=14, 15, 24$ , and 28 populations (table 1) and *M. guttatus* has  $n=14, 15, 16$ , and 28 populations (table 1). Another series occurs in three closely related species of the *M. luteus* complex. *Mimulus tigrinus* has  $n=30$  and 32; *M. luteus* has  $n=30, 31$ , and 32; and *M. cupreus* has  $n=31$  and 32 chromosomes. Perhaps further counts will complete these series of chromosome races and reveal the presence of other such parallel series in section *Simiolus*.

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## A RUST ON ANEMOPSIS CALIFORNICA

PAUL D. KEENER and JACK E. HAMPTON

The discovery of aecia on leaves of *Anemopsis californica* (Nutt.) H. & A., at three locations in Lincoln Co., Nevada (fig. 1) represents the first record of any stage of a rust fungus on plants of the Saururaceae in North America. *Uredo houltuyniae* Sawada has been reported on *Houltuynia cordata* Thunb., a saururaceous species, in Formosa (Sawada, 1944). *Uromyces saururi* P. Henn. is known to occur on *Saururus chinensis* Hort., in China (Cummins and Ling, 1950) and on *S. loureiri* Decne, in Japan (Hiratsuka, 1955).

Collections of infected *Anemopsis* (Yerba-mansa) were made at Hiko, Crystal Springs, and Ash Springs on September 20, 1965. The average numbers of aecial sori per leaf from 10 randomly selected samples from each location were: Hiko, 0.3; Crystal Springs, 0.5; and Ash Springs, 1.34. At the two latter locations, infected plants appeared as if burned. Many of the sori and aeciospores were partially or completely destroyed by *Tuberculina persicina* (Ditm.) Sacc., a hyperparasite. Aeciospores were obtained for morphological comparisons; germination was poor, and inoculations on associated hosts, chiefly Gramineae, were unsuccessful.

Intermixed with rusted *Anemopsis* were plants of saltgrass, *Distichlis stricta* (Torr.) Rydb., bearing uredia and telia. This rust was most prevalent on saltgrass leaves adjacent to or in contact with heavily rusted Yerba-mansa. The rust on *Distichlis* was identified tentatively as *Puc-*

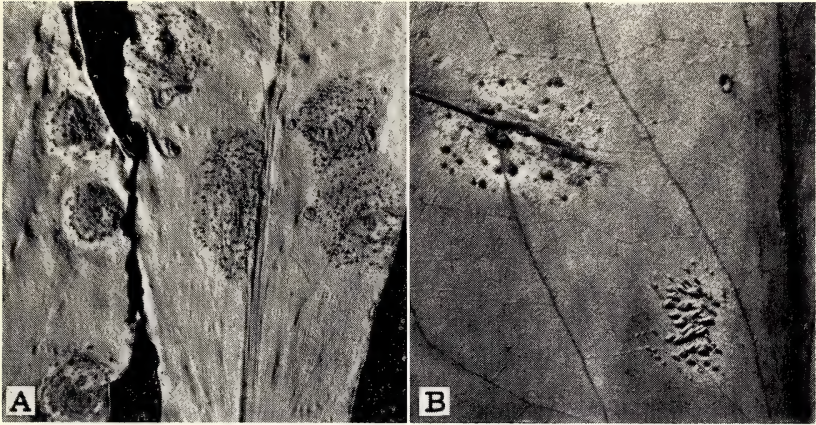


FIG. 1. Aecial sori of a rust on leaves of *Anemopsis californica*: A, Numerous grouped sori some of which are altered (at left) by presence of *Tuberculina persicina*, a fungus attacking rusts; B, Enlarged views of aecial sori. Lower right, normal appearing cylindrical shaped structures. Upper left, a group of sori bearing dark-colored hyphae and spores of *Tuberculina persicina*.

TABLE 1. COMPARISON OF AECIAL CHARACTERS OF A RUST ON ANEMOPSIS CALIFORNICA FROM 3 LOCATIONS IN NEVADA WITH THOSE OF PUCCINIA ARISTIDAE.

Rust	Position of aecial sori	Aeciospores			Peridial cells (Microns)
		Size (Microns)	Wall Thickness (Microns)	Ornamen- tation	
From Hiko	Hypophyllous	14-19 × 17-23	1-3	Finely Verrucose	16-24 × 21-28 Verrucose
From Crystal Springs	Hypophyllous	14-19 × 17-24	1-3	Finely Verrucose	12-23 × 22-31 Verrucose
From Ash Springs	Generally Hypophyllous but some amphigenous	16-20 × 17-23	1-3	Finely Verrucose	16-24 × 21-26 Verrucose
<i>Puccinia aristidae</i>	Chiefly hypophyllous	13-21 × 15-23	1-3	Finely Verrucose	not given

*cinia aristidae* Tracy, although Cummins and Husain (1966) consider *P. subnitens* Diet. on *Distichlis* to be distinct from *P. aristidae* on *Aristida*. Comparisons of aecia-aeciospore morphology from the 3 Nevada localities with date reported for *P. aristidae* (Arthur, 1962) are given in Table 1.

The spermatogonia and aecia of *Puccinia aristidae* have been reported as occurring both naturally and experimentally on numerous species of both Monocotyledoneae and Dicotyledoneae. Arthur (1962) lists 104



species in 66 genera of 22 families as being susceptible to the rust, (but see Cummins & Husain). In Nevada, 12 species in 11 genera of 7 families are listed as susceptibles.

This paper has been approved as Journal Paper No. 1191, Arizona Agricultural Experiment Station. The late Dr. Keener was Professor of Plant Pathology at the University of Arizona.

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#### REVIEWS

*Polyporaceae of North America. The Genus Poria.* By JOSIAH L. LOWE. 183 pp., 159 line drawings. Technical Bulletin No. 90. State University College of Forestry at Syracuse University, New York. 1966.

The genus *Poria* is generally considered one of the most difficult of the genera in the Polyporales, and a modern, thorough treatment such as this constitutes a most welcome addition to the literature. Taxonomic keys and descriptions of approximately 130 species are presented plus descriptions of several species belonging to related genera that might be confused with those of *Poria*. By use of color of the pore surface and type of hyphal system the genus is divided into five sections. Because this arrangement is apparently still somewhat tentative the sections were left unnamed. The species descriptions contain sufficient details of both macroscopic and microscopic characters to enable one to feel relatively confident of his determinations. No new species or combinations are presented. A short introduction and discussion of the morphology, distribution and economic importance of the genus precedes the taxonomic treatment.

Attempts at using the keys were usually successful, but it seems however, that some improvement in their construction could have been made. For example, opposing choices could have been kept adjacent to one another thus eliminating the necessity of searching through several pages for the second choice. The use of such terms in the choices as "frequently," "usually," etc. tends to destroy one's confidence in the keys and thus increase the difficulty of determinations. In this same category, but somewhat more displeasing, is the use of "large" or "small" in referring to size of various structures or cells without giving more precise measurements. One final observation is that perhaps if a few photographs had been included, the use of the manual would have been enhanced, at least for use in advanced classes. Typographical errors are few and of minor significance. None of these criticisms are intended to seriously detract from the real value of this publication, and it will be of considerable value to all working with these fungi.—HARRY D. THIERS, Department of Biology, San Francisco State College.



*The Komarov Botanical Institute, 250 Years of Russian Research.* By STANWYN G. SHETLER. xiv + 240 pp., illus. Smithsonian Institution Press, Washington, D.C. 1967. \$5.95.

In recent decades biologists have largely relegated the art of biological historiography to historians. The result is that accounts of the development of biological ideas and institutions show insights into the cultural and political milieu, but often lack perspective when considering the biological Zeitgeist of the period or events covered. Therefore it is refreshing that a botanist has written a balanced and interesting account of the evolution of one of the world's largest and most prominent botanical institutions—the Komarov Botanical Institute in Leningrad. Most American systematists are aware that such an institute exists, know that it probably has the largest herbarium in the world, but would be hard-pressed to continue discussion beyond this point. Stanwyn Shetler's comprehensive treatment of the 250-year history of the institute will alleviate our collective gaps in knowledge of this important center of taxonomic and floristic research.

The first part of the book deals with the establishment of St. Petersburg and its transition into modern Leningrad, a city which provides frustration as well as delight to a tourist. The second part of the book concerns the development of the Imperial Botanic Garden in St. Petersburg and the Botanical Museum of the Academy of Sciences. The botanic garden eventually came under the aegis of the Academy of Sciences and in 1931 it was decided that the two organizations should be united as the Botanical Institute of the Academy of Sciences of the U.S.S.R. In 1940, the Botanical Institute was named after V. L. Komarov, a distinguished botanist who organized the monumental Flora SSSR project which was completed in 1964. At present, the institute has a "staff of 700, two dozen major laboratories, a large greenhouse and outdoor garden complex, an arboretum-park, several experimental farms, a 450,000-volume library, and combined herbaria of nearly 6 million specimens"! Administratively, the Institute consists of departments of Vascular Plants (headed by Armen Takhtajan); Cryptogamic Plants (M. M. Hollerbach); Geobotany (B. A. Tikhomirov—whom some readers may know personally since he was a relatively communicative attendee at two recent International Botanical congresses); Plant Resources (Economic Plants [A. A. Federov]); Evolutionary Morphology (M. S. Yakovlev); Botanic Garden (N. A. Avrorin); Botanical Museum (F. Kh. Bakhteev); and two physiological-biochemical departments: Photosynthesis and Microelements. Thus, the massive staff and facilities of the Institute are largely devoted to systematic studies; such concentrated resources are unparalleled in the western world. The third and final part of the book is a summary of previous chapters and also discusses the future of the Institute. The latest Five-Year Plan for the Institute calls for continuation of present efforts in floristics, systematics, and geobotany (which in current Russian usage "refers to the general study of *vegetation*—its origin, development, distribution, and utilization (especially).") With the revival of Mendelian genetics in the Soviet Union it seems likely that biosystematic studies will resume as well. In the international field, the Institute anticipates a strong role in the International Biological Program, and Shetler suggests that the Russians may initiate intensive studies in the tropics. He adds that "because much exploratory research on the tropics must necessarily proceed along classical lines, Soviet botany may actually be in a better posture today for tropical studies than American botany, owing to the stronger persistence of classical methodology and greater sympathy for herbaria in the USSR."

Shetler's book is lucid and straightforward; it is well illustrated with scenes of Leningrad, of the Institute, and most valuably, of the principal present and past staff members of the Institute. Its parallel usage of Cyrillic and Roman characters for Russian words and names will enhance the utility of the book for librarians and bibliographers. I cannot predict how this study will be received by the Russians, but it is a dispassionate and comprehensive presentation which is most welcome to us in the West.—ROBERT ORNDUFF, University of California, Berkeley.

*A Field Guide to the Natural History of the San Francisco Peninsula.* By JOHN C. WILLIAMS and HOWARD C. MONROE. xvi + 285 pp., illustrated with numerous line drawings and photographs. McCutchan Publishing Corp., 2526 Grove St., Berkeley, Calif. 94704. Spiral bound, \$5.50; hardback, \$7.50.

In the preface to this book the authors state that: "The idea behind this book is to foster an understanding of the natural history of our surroundings so that we may better understand the potentials and cope with the problems of our environment." This is certainly a good idea and we need many more interpretive manuals. The book is divided into nine parts: introduction, bay and salt marsh, the open coast, the chaparral, the grasslands, the broadleaf forests, the cone forest, appendix, and index. The grouping of organisms by community (parts 2-7) is a good way of arranging the material.

Unfortunately, though, this guide falls far short of its goals because of the numerous factual errors. A few examples from the botanical contents of the guide, *alone*, will indicate why this is so.

One page 27, *Typha latifolia* is in the checklist of coastal and bay salt marsh plants and animals.

*Pinus radiata* (p. 48) does not "grow wild along much of the coast."

"Weeds of the genera *Brassica* ssp., *Camelina* spp., *Capsella* spp., are found all through the coastal strand." This statement from page 51 is true for *Brassica* and *Capsella*, but not for *Camelina*.

The picture labelled Morning Glory (p. 52) is actually one of *Senecio mikanoides* not of *Convolvulus soldanella* and that of Spearmint (p. 109) is *Stachys*, not *Mentha spicata*.

One page 109 we find: "Spanish Bayonet (*Yucca* spp.) is common in the southern or high chaparral." *Yucca whipplei* is known from Monterey County, but that county is not part of the San Francisco Peninsula by any stretch of the imagination. And on page 123 the Spanish Bayonet is called *Yucca schidigera*!

On page 131 we learn that Black Acacia is *Acacia melanoxia*, on p. 137 that Soft Cheat is *Bromus hordeaceus*, on page 134 that California Needle Grass is *Stipa pulchra*, on page 135 that Indian Thistle is *Cirsium edule*, and on page 141 that the California Golden Poppy is *Eschscholtz californica*. Errors of this kind are found on nearly every page.

On page 173, we find the myth perpetuated that "The California Laurel or Bay (*Umbellularia californica*) is the 'Myrtle' of the Bible."

*Vitis californica* (p. 175) does not grow natively on the San Francisco Peninsula and certainly is not "common."

The drawings on page 266 which are supposed to show differences between superior and inferior ovaries indicate that the authors do not understand the arrangement of parts in the flower.

A thorough revision of this book is necessary before it can be used.—JOHN H. THOMAS, Dudley Herbarium, Stanford University.

## NOTES AND NEWS

### NEW PUBLICATIONS

*Checklist of Vascular Plants of the Intermountain Region* By ARTHUR H. HOLMGREN and JAMES L. REVEAL. iv + 160 pp. U.S. Forest Service Research Paper INT-32. 1966. Intermountain Forest and Range Experiment Station, Ogden, Utah.

*Interspecific Relationships in the Genus Monarda (Labiales).* By RAINER W. SCORA. University of California Publications in Botany 41:1-71. University of California Press, Berkeley and Los Angeles. 1967. \$2.50.

*Memorials of John Bartram and Humphry Marshall.* By WILLIAM DARLINGTON. Introduction by JOSEPH EWAN. lii + 585 pp. (Facsimile of the edition of 1849). Hafner Publishing Co., 31 E. 10th St., New York. 1967. \$20.00

- Bibliography of Utah Botany and Wildlife Conservation.* By EARL M. CHRISTENSEN. Brigham Young University Science Bulletin, Biological Series 9(1):1-136. Provo, Utah. 1967.
- Guide to the Woody Plants of Utah.* By MICHAEL TRESHOW, STANLEY L. WELSH, and GLEN MOORE. 161 pp. illus. Pruett Press, Inc., Boulder, Colorado. 1964. \$3.00
- Mountain Plants of Northeastern Utah.* By BERNIECE A. ANDERSON and ARTHUR H. HOLMGREN. 148 pp., illus. Circular 319, Utah State University Extension Services, Logan. 1966. \$1.25.
- Trees and Flowering Shrubs of Yellowstone and Grand Teton National Parks.* By RICHARD J. SHAW. 50 pp., illus. in color. Wheelright Press, 975 SW Temple, Salt Lake City, Utah. 1964. \$1.00.
- World Vegetation.* By DENIS RILEY and ANTHONY YOUNG. 96 pp. Cambridge University Press. 1966.
- Native Trees of Canada.* xviii + 291 pp., illus. Bull. 61, Department of Forestry. Queen's Printer, Ottawa. 6th edition, 1966 reprint. \$3.00.
- Wild Plants of the Canadian Prairies.* By ARCHIBALD C. BUDD and KEITH F. BEST. viii + 519 pp., illus. Publication 983, Research Branch, Canada Department of Agriculture. Queen's Printer, Ottawa. 1964. \$3.00, paper; \$4.00, cloth.

VALIDITY OF NOMENCLATURE CHANGES UNDERTAKEN IN THE FLORA OF ALASKA AND YUKON.—In *Arkiv för Botanik*, Ser. 2., 7(1):1-147. 1967, edited by the Swedish Academy of Sciences, a number of nomenclatorial changes in the flora of Alaska and Yukon were made. Unfortunately some of them were not validly published in accordance with the Code of International Botanical Nomenclature. They are validated below:

Page 23. *Eriophorum callitrix* var. *pallidus* Hultén, var. nov. Type in S. According to Marcel Raymond, Montreal, it is the same as var. *moravium* Raymond (Bull. Soc. Bot. Fr. 98:7. 1951).

Page 35. *Platanthera saccata* (Greene) Hultén, comb. nov. Add: *Habenaria saccata* Greene (*Erythea* 3:49. 1895).

Page 52. *Minuartia yukonensis* Hultén, sp. nov. Type is S.

Page 59. *Ranunculus gelidus* ssp. *grayi* var. *shumaginensis* Hultén, var. nov. Type in S.

Page 60. *Papaver hulténii* var. *salmonicolor* Hultén, var. nov. Type in S.

Page 62. *Cardamine bellidifolia* var. *pinatifida* Hultén, var. nov. Type in S. *Cardamine purpurea* var. *albiflos* Hultén, var. nov. Type: Alaska, McKinley Park Highway, mile 63.5, Throughfare Pass, July 1964, Hultén, S.

Page 64. *Draba stenopetala* var. *purpurea* Hultén, var. nov. Type in S.

Page 66. *Braya bartlettiana* var. *vestita* Hultén, var. nov. Type in S.

Page 67. *Parrya nudicaulis* ssp. *septentrionalis* Hultén, ssp. nov. Type in S.

Page 68. *Saxifraga foliolosa* var. *multiflora* Hultén, var. nov. Type in S.

Page 69. *Saxifraga nivalis* var. *rufopilosa* Hultén, var. nov. Type in S.

Page 71. *Rubus arcticus* ssp. *arcticus* var. *pentaphylloides* Hultén, var. nov. Type in S.

Page 101. *Diapensia lapponica* var. *rosea* Hultén, var. nov. Type in S.

Page 113. *Polemonium boreale* var. *villosissimum* Hultén, var. nov. Type in S.

Page 122. *Pedicularis labradorica* var. *sulphurea* Hultén, var. nov. Type in S. *Pedicularis langsdorffii* ssp. *arctica* (R. Br.) Pennell should be cited as *P. langsdorffii* ssp. *arctica* (R. Br.) Pennell ex Hultén.

Page 134. *Antennaria friesiana* ssp. *alaskana* var. *beringensis* Hultén, var. nov. Type in S.

Page 135. *Antennaria monocephala* ssp. *philonipha* var. *latisquamea* Hultén, var. nov. Type in S.

Page 139. *Artemisia glomerata* var. *subglabra* Hultén, var. nov. Type: Alaska, Kagati Lake, Sept. 12, 1965, Hultén, S.—ERIC HULTÉN, Naturhistoriska Riksmuseet, Stockholm, Sweden.



THREE ROADSIDE GRASSES AS RECORDS FOR SACRAMENTO, EL DORADO, AND PLACER COUNTIES, CALIFORNIA.—The following grasses occur on gravelly to sandy road-shoulders or on roadbanks of similar texture. Seldom, if at all, do they penetrate beyond into areas where competition is greater and summer moisture is wanting. Two major highways, Interstate Highway 80 (U.S. Highway 40) and U.S. Highway 50 in the area east of Sacramento are the subject of this study. Collections were made during July and August, 1967 unless otherwise noted. The two perennial species at all locations are in the second, third, or more year's growth. All collections cited are by the author and are deposited in AHUC.

*Panicum hillmanii* Chase. This grass readily spreads by the large panicles which break away from the stem and are carried by the wind as "tumbleweeds." The plant extends through Sacramento County along both highways to the Placer and El Dorado county lines (8135, 8136, 8143, 8169, 8173). Currently, the best stand occurs along Interstate Highway 80 between Arden Way and Marconi Avenue in Sacramento.

*Sporobolus cryptandrus* (Torr.) A. Gray. The commonest grass of the three occurring along both highways into the Sierra Nevada to about 3000 feet elevation (8142, 8144, 8145, 8146, 8148, 8156, 8157, 8158, 8163, 8165, 8166, 8171). The grass was first noted in Sacramento County near the Nimbus Road exit, U.S. Highway 50, June 3, 1965 (7363).

*Chloris verticillata* Nutt. The unique inflorescence of this grass readily disarticulates as a unit from the stem below the radiating spikes and behaves as a tumbleweed facilitating its spread along roadshoulders. It occurs along Interstate Highway 80 from east of Sacramento about the 1500 ft. elevation in the Sierra Nevada (8164, 8170, 8172, 8177, 8178). A single collection was made along U.S. Highway 50, 2.5 miles west of Shingle Springs in El Dorado County (8147). At nearly all locations the grass occurs in association with *Sporobolus cryptandrus* and *Eremocarpus setigerus* Benth. At one location between Sacramento and Roseville the grass appears to be in at least the third season of growth.—BEECHER CRAMPTON, Department of Agronomy, University of California, Davis.

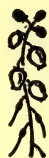
A NEW FAMILY OF VASCULAR PLANTS (PSILOACEAE) FOR ARIZONA.—Sycamore Canyon located about twenty miles west of Nogales in Santa Cruz County, Arizona, has long been noted for its interesting and unusual flora (Goodding, Jour. N. Y. Bot. Gard. 47:86-97. 1946; Jour. Ariz. Acad. 1:113-115. 1961). It is the type locality for *Fraxinus gooddingii* Little which is found outside the canyon only in the adjacent Peña Blanca drainage area. Several Mexican species *Dalea lagopus* (Cav.) Willd., *Lotus alamosanus* (Rose) Gentry, and *Passiflora bryonioides* H.B.K., are found in the United States only in Sycamore Canyon; likewise, *Asplenium exiguum* Bedd, known from Asia, and Northern Mexico, occurs in Sycamore and Garden Canyons in Arizona. Several other species, including *Dichondra sericea* Sw., *Aloysia lycioides* Cham., *Tilandsia recurvata* L., and *Aeschynomene villosa* Poir. having irregular, disjunct distributions, grow in this rugged and picturesque area.

A recent find in Sycamore Canyon adds a new family and order to the known flora of Arizona. *Psilotum nudum* (L.) Griseb. was collected by Mr. Jack Kaiser of the U.S. Department of Agriculture, from a rock crevasse on a protected west exposure. This locality is about 300 miles north of the closest known population in Sonora, Mexico, as reported by Gentry (Carnegie Inst. Pub. 527:328. 1942), and is many miles north and west of the areas near Chihuahua, in the State of Chihuahua, Mexico (Knoblock and Correll, Contr. Texas Res. Found. 3:198. 1962). The closest recorded locality for *Psilotum* in the United States is Hardin County in eastern Texas (Knoblock, Wrightia 2:163-165. 1961).

The specimen is on file in the University of Arizona Herbarium. This paper is Arizona Agricultural Experiment Station Journal Article number 1329.—CHARLES T. MASON, JR., Herbarium, The University of Arizona, Tucson.



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# MADRÑO

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## THE VEGETATIONAL COMPOSITION OF THE SOUTH SLOPE OF MT. PINOS, CALIFORNIA

RICHARD J. VOGL and BRIAN C. MILLER

An ecological study of the vegetational composition of the coniferous forest on the south half of Mt. Pinos was conducted from 1962 to 1966. The mountain is located on the Kern-Ventura County line at the extreme south end of the San Joaquin Valley. The south face rises sharply from Lockwood Valley (5500 ft. elevation) up a steep grade, interrupted by minor canyons, valleys, and ridges, to the summit at 8831 ft. elevation. The slope drains by way of Lockwood and Piru Creeks and the Santa Clara River into the ocean, about 40 miles away. The area was selected because of its accessibility and interesting flora, and because the forest was relatively undisturbed.

Geologically Mt. Pinos is bounded on the north by the San Andreas Fault and on the south by the Big Pines Fault. Formation of the granite core of the mountain is believed to have occurred sometime during the Jurassic Period (Jenkins and Kundert, 1955). In most areas the granite bedrock has decomposed to form soils, but on actively eroding sites and rises, the bedrock is still evident. The soils are composed of a mixture of coarse-grained and extremely fine particles of granitic material, are slightly acid, and are covered by pine duff up to 4 inches in depth.

The climate of the mountain is relatively dry. Precipitation data was unavailable for the mountain, but an average rainfall of 12.5 inches per year based on a 22 year average (1941-1963) was recorded at Chuchupate Ranger Station in Lockwood Valley. Major precipitation falls there from December through March, with snow predominant in February and March. Precipitation on the mountain is undoubtedly higher than that of the valley. These higher amounts are perhaps illustrated by the seven-year mountain summit snow depth records kept by the Forest Service. Snow depths averaged 32.4 inches on March 1 and 18.2 inches on April 1. It is generally accepted that 10 inches of snow roughly corresponds to 1 inch of rain (Oosting, 1958). Rainfall during the remainder of the year probably averages about one-half inch per month, although the summer months are commonly without precipitation except for small local thundershowers. A rain shadow produced by the coast ranges affects the mountain as it does the San Joaquin Valley. For example, Ojai, 12 miles from the coast at 750 ft. elevation, has an average annual rainfall of 21.6 inches, whereas Maricopa, on the San Joaquin Valley edge about 45 miles inland and 854 ft. above sea level, receives an average of only 5.7 inches of rain (U.S. Dept. Agr., 1941). The climate is typically Mediterranean, but at the same time somewhat continental and more characteristic of arid inland mountains than of adjacent coast ranges with maritime influence.



## METHODS

A species list was compiled. Eight sample sites or stands ranging from the base to the summit were selected. Although the entire mountain had been grazed by cattle, each stand was free from logging and road building disturbances and was at least an 8 acre uniform representation of a vegetational association.

In each stand 80 trees and 80 saplings were sampled with the point-centered quarter method (Cottam and Curtis, 1956). Individuals were classed according to forestry standard sizes with those over 4 inches in diameter grouped as trees, those 1–4 inches as saplings, and those less than 1 inch as seedlings. Twenty-five foot line-intercepts were placed systematically at every other point to sample the understory shrub and herb cover. Sapling and tree increment borings were taken to obtain age and growth rates. Stump ring counts were made on trees removed in a partial logging-cut completed near the termination of the study. Counts of lightning-damaged trees were made on the upper one-third of the slope. An Importance Value (I.V.) was obtained for each tree species by summing its relative frequency, density, and dominance. Since dominance (basal area) of saplings was not taken, the relative frequency and density of each sapling species were totaled and multiplied by a factor of 1.5 to obtain values comparable to tree I.V.'s.

Nomenclature of species follows Munz (1959). Voucher specimens are in the herbarium at California State College at Los Angeles. A problem of species identification existed between *Pinus ponderosa* and *P. jeffreyi* at lower elevations where trees were found with intermediate characteristics. Because of this variability, trees were classified using the criteria suggested by Haller (1962). Based upon these criteria, the study trees were considered to be *P. jeffreyi*.

## RESULTS AND DISCUSSION

*Pinus monophylla* was the most common tree at lower elevations (5500–5700 ft.). Table 1 lists the average sizes, numbers per acre, and I.V.'s of the trees and saplings. *Pinus jeffreyi* began to appear in stand two at 5700 ft. elevation, along with a few tree-sized *Quercus turbinella* ssp. *californica*. From about 6000 ft. to the summit, *P. jeffreyi* was the most important tree. In stand four at 6900 ft., *P. jeffreyi* appeared savanna-like with 22 trees per acre scattered across a light grassy understory. *P. jeffreyi* was associated with *Quercus kelloggii* along canyon bottoms and on southeastern exposures. Occasional *Quercus chrysolepis* were also found at mid-elevations. Starting about 7750 ft. (stand six), *P. jeffreyi* was associated with an occasional *Abies concolor*, particularly on slopes with northerly exposures. The *P. jeffreyi* forest on the upper slopes (8750 ft. elevation) consisted of large (48 inch dbh) and medium-sized pines with densities of about 105 trees per acre (fig. 1).

The sapling layer was related and similar to the tree layer in compo-



TABLE 1. SIZE, DENSITY, AND IMPORTANCE VALUES OF TREES AND SAPLINGS.

Stand No.	Species	Avg. Basal Area per tree (in. <sup>2</sup> )	Trees-Saplings per acre		Trees-Saplings I.V.	
1	<i>Pinus monophylla</i>	64	85	61	288	152
	<i>Quercus turbinella</i>	18	2	61	12	148
2	<i>P. jeffreyi</i>	367	11	1	138	31
	<i>P. monophylla</i>	73	20	10	132	175
	<i>Q. turbinella</i>	19	4	5	30	94
3	<i>Abies concolor</i>	-----	-----	0.2	-----	7
	<i>P. jeffreyi</i>	391	27	10	191	237
	<i>P. monophylla</i>	32	2	-----	12	-----
	<i>Q. chrysolepis</i>	-----	-----	0.2	-----	7
	<i>Q. kelloggii</i>	153	18	1	97	48
4	<i>P. jeffreyi</i>	667	22	4	287	266
	<i>P. monophylla</i>	72	1	0.1	7	16
	<i>Q. chrysolepis</i>	211	0.3	0.2	6	18
5	<i>P. jeffreyi</i>	309	63	13	287	250
	<i>P. monophylla</i>	32	2	0.2	7	8
	<i>Q. chrysolepis</i>	12	1	1	6	42
6	<i>A. concolor</i>	855	3	1	44	30
	<i>P. jeffreyi</i>	297	33	13	256	270
7	<i>A. concolor</i>	349	1	1	12	17
	<i>P. jeffreyi</i>	534	50	26	288	283
8	<i>A. concolor</i>	-----	-----	0.1	-----	9
	<i>P. jeffreyi</i>	697	105	7	300	291

sition, but contained much lower densities. In stands one and two, tree reproduction consisted of about equal amounts of *P. monophylla* and *Quercus turbinella* (table 1). A few sapling-sized *P. jeffreyi* were also present in stand two. In stand three (6500 ft. elevation), *P. jeffreyi* and *Q. kelloggii* dominated the sapling as well as the tree layer. A few *Abies* and *Q. chrysolepis* saplings were also found. In stand four tree reproduction was represented by a limited number (four per acre) of *P. jeffreyi* with lesser numbers of *Q. chrysolepis* and *P. monophylla*. There were five times more trees than saplings in stand five at 7400 ft. elevation. The sapling layer in the upper elevational stands was dominated by low densities of *P. jeffreyi*. *Abies* saplings were most common on northern exposures. Tree reproduction was minimal throughout the mountain-side. *Pinus jeffreyi* was the most important species, except for *P. monophylla* at the lowest elevations and the scattered *Abies* saplings at the highest elevations.

Shrub cover was sparse over most of the area. Common lower elevational shrubs were *Quercus turbinella*, *Artemisia tridentata* and *Yucca whipplei* (table 2). *Symphoricarpos parishii* was most common at mid-elevations (1.2% cover). Some of the steeper slopes at these elevations were treeless and occupied entirely by an impenetrable cover of *Ceano-*



FIG. 1. *Pinus jeffreyi* forest at 8800 ft. elevation. The large trees, sparse number of saplings, and almost complete lack of herbaceous layer give the forest a park-like appearance. The large tree on the right has been damaged by lightning.

*thus cordulatus* which grew to an average height of 3 ft. Other local areas were occupied by *Chrysothamnus nauseosus* ssp. *mohavensis*. The upper forest was dominated by *Symphoricarpos* which reached its greatest abundance of 23% cover in stand seven (table 2). *Ribes cereum* was locally important in openings and around rocky outcrops at upper elevations.

Herbaceous vegetation was sparse and discontinuous (table 2). In stand one, 54.3% of the sample area was devoid of plant cover (table 2). *Sitanion jubatum* was most common in stands one and two and was the most widespread herb since it was found in all stands. *Bromus tectorum* dominated the forest floor in stand two with 28.8% cover which was slightly more than all of the 20 other herbaceous species combined. Cover in stand three was dominated by *Sitanion*, *B. tectorum*, *Poa nervosa*, and *Hesperochloa kingii* giving it a somewhat grassy appearance. Small forbs mixed with the grasses included *Gayophytum diffusum*, *Eriogonum latifolium* ssp. *pauciflorum*, *Penstemon labrosus*, *Erysimum capitatum*, and *Galium aparine*. In stands four through eight (6900–8750 ft. elevation) the sparse herbaceous layer consisted of infrequent grasses and forbs such as *Gayophytum*, *Eriastrum sapphirinum* ssp. *ambiguum*, *Collinsia torreyi* var. *wrightii*, *Gilia modocensis* type *tetra-breccia*, *Penstemon labrosus*, *Lupinus confertus*, and *L. elatus*, which provided less than 1% cover per species. Stand eight, near the mountain summit, contained the greatest herb variety, probably because of the proximity of forest openings and the summit meadow.

TABLE 2. PER CENT COVER OF DOMINANT AND SUBDOMINANT UNDERSTORY SPECIES

Species	Stands							
	1	2	3	4	5	6	7	8
<i>Artemisia tridentata</i>	0.1%	6.8%	0.5%	%	%	%	%	%
<i>Quercus turbinella</i> (shrubs)	42.1							
<i>Sitanion jubatum</i>	2.1	1.0	3.4	3.8	1.0	0.7		
<i>Pinus monophylla</i> (seedlings)	0.6							
<i>Bromus tectorum</i>		28.8	1.6		5.4			
<i>Hesperochloa kingii</i>		0.9		3.0				
<i>Eriogonum latifolium</i>					0.7			
<i>E. kennedyi</i>				1.9				
<i>Erigeron foliosus</i>				1.7				
<i>Gayophytum diffusum</i>						0.5	0.1	
<i>Eriastrum sapphirinum</i>						0.1		
<i>Symphoricarpos parishii</i>						10.2	23.3	14.5
<i>Collinsia torreyi</i>							1.6	0.2
<i>Penstemon labrosus</i>							0.3	
<i>Lupinus confertus</i>								4.0
<i>Achillea lanulosa</i>								0.8

A rolling meadow occurred around the mountain summit. This opening contained many of the same species found in the upper forest, but was dominated by dwarf *Chrysothamnus*. About 50% of the area was covered by prostrate, cushion, or mat-forming species such as *Astragalus purshii* var. *longilobus*, *Phlox diffusa* ssp. *subcarinata*, *Calyptri-dium umbellatum*, *Pedicularis semibarbata*, and *Allophyllum violaceum*. These plants and the treelessness of the meadow gave it an almost alpine aspect. The meadow was surrounded by *Pinus jeffreyi* with occasional trees growing in the meadow, except on the north rim where old *P. flexilis* and *Abies concolor* occurred. Some of these trees were without leaders, or were wind-topped or flagged, indicating that the summit approaches climatic timberline.

In addition to the summit meadow, hydric associations dominated by *Iris missouriensis* occurred at upper elevations around seeps and springs. Other plants found in these wet pockets included the more common *Carex athrostachya*, the conspicuous *Veratrum californicum*, and occasional individuals of *Barbarea orthoceras*, *Equisetum junstoni*, *Hele-nium bigelovii*, *Juncus balticus*, *Linum perenne* ssp. *lewisii*, *Mimulus guttatus*, *M. primuloides*, *Perideridia parishii*, *Potentilla glandulosa*, *Ranunculus cymbalaria* var. *saximontanus*, *Sisyrinchium bellum*, *Smil-acina stellata*, *Sphenosciadium capitellatum*, *Stachys albens*, and *Veronica americana*.

A total of 46 families and 178 species were encountered. The largest percentages of species belonged to the Compositae (12.4%), Scrophu-lariaceae (8.4%), Leguminosae (7.5%), Onagraceae (3.9%), Polygona-ceae (3.4%), and Gramineae (3.4%).

As in many California mountains and mountain ranges (Stebbins and Major, 1965), Mt. Pinos has a few endemic species, including *Gilia*



*modocensis* type *tetrabreccia* which occurred in stands five through seven, *Monardella linoidea* ssp. *oblonga* found in stand five, and *Lesingia germanorum* var. *tenuis* which was not sampled, but was present on the south slope.

Because of its central position, the Mt. Pinos flora contained plants also found in the San Joaquin Valley, Sierra Nevada, coast and transverse ranges, and the nearby desert (Munz, 1959). The Antelope Valley portion of the Mojave Desert is within 25 miles of Mt. Pinos and the desert flora was represented by such species as *Anisocoma acaulis*, *Calochortus kennedyi*, both uncommon, and *Chrysothamnus nauseosus* ssp. *mohavensis*. The adjacent Central Valley was represented by *Convolvulus malacophyllus* ssp. *pedicellatus* which was common at mid-elevations, and *Haplopappus acradenius* ssp. *bracteosus* which only occurred at the slope base. The Sierra Nevada range is connected to Mt. Pinos by the Tehachapi Mountains and was represented by two uncommon species, *Ribes velutinum* and *Astragalus whitneyi*.

Tree species common to adjacent ranges, such as *Pinus lambertiana*, *P. coulteri*, *P. sabiniana*, *P. murrayana*, and *Libocedrus decurrens*, were not encountered on the south slope.

The wet iris meadows species have particularly wide distributions since most are found throughout western North America and some are common throughout the United States. Many are northern species, typical of the Sierra Nevada, Rockies, and parts of Canada which have apparently persisted in the semi-arid Southwest by occupying hydric habitats. Some of these species reach their southern limits in the vicinity of Mt. Pinos (Munz, 1959).

*Abies concolor* reproduction occurred both above and below the existing range of *Abies* trees and grew under *Pinus jeffreyi*, indicating that the present *P. jeffreyi* forest could possibly be replaced by *Abies* (table 1). Merkle (1954) made similar observations in ponderosa forests near Grand Canyon, Arizona. *Abies* might be able to replace *P. jeffreyi* because it is more shade tolerant and can thus become established under *P. jeffreyi* canopies. *Abies* seedlings can survive lower temperatures than yellow pine, and can grow on accumulated litter and organic matter (Toumey and Korstian, 1962). *Abies* is considered the most mesic conifer in southern California mountains, and, when it dominates a stand, other conifers, including *P. jeffreyi*, do not appear to become successfully established or grow under its dense canopies.

Pearson (1930) found that mature *Pinus ponderosa*, which is similar to *P. jeffreyi*, does not utilize moisture in the top 1 ft. of soil because of its deep tap root system. *Abies'* moderately shallow, plate root system (Davis, 1959) could enable it to utilize this surface moisture, and thus become well established before having to compete directly with the mature *P. jeffreyi* for deeper soil moisture. Observations of *Abies* growing immediately under and next to *P. jeffreyi* tend to support this hypothesis.

Ecologically, *Abies* appears to be the successional stage to replace



much of the *P. jeffreyi* forest since it is the most shade tolerant, but apparently on Mt. Pinos, at least in the past, succession has been continually retarded by disturbance factors.

Although there were no ungrazed areas available for comparison, it is probable that grazing has affected succession. Cattle, deer, and rabbits destroy pine and fir seedlings by severe browsing and girdling. Stunted *Abies* retarded by continual browsing were observed. One seedling-classed *Abies* suppressed by constant deer browsing was 1 ft. high, one-half inch in diameter, and 65 years old. Cattle grazing and concentrations of burrowing rodents have undoubtedly caused the invasion of *Artemisia tridentata* and *Chrysothamnus nauseosus* by the elimination of the more palatable grasses and forbs and the creation of disturbed sites as they have done elsewhere (McKell and Chilcote, 1957).

Sparse understory is unique to southern California (fig. 1) because early descriptions of similar pine forests of other areas indicate that a grass cover was the most striking feature of the understory (Pearson, 1951; Weaver, 1951; Cooper, 1960). If grasses were originally abundant on Mt. Pinos, overgrazing would be the most plausible explanation for their disappearance, but this appears to be unlikely. Grazing probably reduced native perennial grass and forb cover on areas presently occupied by *Chrysothamnus*, *Artemisia*, and *Bromus tectorum*. Savanna areas were probably more extensive before the advent of fire protection and offered more acreage than now present for the establishment of grasses. However, it is believed that a dense or continuous understory of grasses and forbs did not exist in the presettlement forest of Mt. Pinos, and that the understory cover was not much denser than it is today. This conspicuous absence, typical of Mt. Pinos and other conifer forests in southern California mountains, is probably produced more by the lack of summer precipitation during the growing season than by disturbance factors. This assumption is supported by Whittaker and Niering's (1965) statement that, although the annual precipitation on southern California Mt. San Jacinto was sufficient to support trees, the shade and root competition of the overstory combined with summer drought severely limited understory development. Forests of inland mountain ranges, such as those in Arizona, characteristically produce more understory cover because of additional summer rainfall (Whittaker and Niering, 1965). The Mt. Pinos forest supported 10–50% (average 34%) grass and forb cover, while pine forests in the Arizona Grand Canyon region supported 40–60% ground cover (Merkle, 1962).

Grass species found on Mt. Pinos were *Bromus carinatus*, *B. tectorum*, *Elymus condensatus*, *Hesperochloa kingii*, *Poa nervosa*, and *Sitanion jubatum*. *Bromus tectorum* was the only introduced annual. Lack of abundant introduced annual grasses which have replaced native perennial grasses eliminated by grazing elsewhere in California (Biswell, 1956; Heady, 1958), also supports the hypothesis that Mt. Pinos has always had sparse understory cover.

Although data are lacking on the past vegetation of Mt. Pinos, nat-

ural fires probably had the same retrogressive influence on the vegetation as they had in other places (Weaver, 1951; Cooper, 1960), and were partially responsible for the present park-like appearance of the forest (fig. 1). United States Forest Service records indicated that 17 fires occurred on the south slope between 1919 and 1950. The majority were lightning-caused and resulted in fires of less than four acres. This low number of lightning-caused fires does not adequately reflect the high incidence of lightning occurring on Mt. Pinos. The upper mountain receives as many as 600 lightning strikes during the summer months, with single storms often producing over 100 strikes (D. Roberts, fire control officer, personal communication). Some of these bolts strike open ground or rock; some hit trees, causing damage or death but not fire, or causing fire which is subsequently extinguished by rain (fig. 1). Occasionally, trees which have previously been injured by lightning, fire, wind, or fungi are ignited, producing "sleepers" that burn out the tree's heartwood. With drying conditions, the "sleepers" may subsequently spread fire to the surrounding area. However, because of fire protection, these fires are usually detected and extinguished before they spread to other vegetation. Other strikes produce fires that burn individual trees or the immediate duff and understory, or fires that crown and burn a small group of trees. The lack of continuous understory and the scattered savanna growth tends to discourage widespread surface or crown fires.

Mature *P. jeffreyi* with evidence of having survived lightning strikes and recurring surface fires were common. A random sample of 277 trees on the upper slope contained 32.5% of the *P. jeffreyi* with lightning damage apparent in the form of spiral trunk or bark splits. Trees with damaged tops were not counted because wind and lightning damage could not be definitely differentiated. *P. jeffreyi* often survives surface fires because of its thick bark and moderately high, open tree crowns. Fifty trees with a 21 inch average dbh had a 2.1 inch average bark thickness. Though mature *Abies concolor* possess thick bark, they are usually less fire resistant than *P. jeffreyi* because the crowns are low and dense and individuals occur close together (Davis, 1959). Twenty *Abies* with an average 23.1 inch dbh had an average bark thickness of 2.5 inches. Young *Pinus* and *Abies* have thin bark and are fire susceptible.

Increment borings and stump ring counts were used to age a total of 75 trees. Data obtained indicated that trees and saplings occurred in small even-aged groups. Small groves of *P. jeffreyi*, consisting of three or more trees of the same age, were found to be 38, 63, 79, 85, 110, 205, 235, 253, 305, 350, and 358 years old. Each age group occurred over less than one-quarter to one acre. Recently cut *P. jeffreyi* near the summit were all about 250 years old. Two larger *Abies* (65 and 70 inch dbh) were of the same age. The pines occurred over about one acre, and probably originated after a lightning fire, since one larger *P. jeffreyi* (56 inch dbh) was over 400 years old and had a deep basal fire scar enlarged by subsequent fires that dated back approximately 250 years.

Apparently, presettlement fires were also local spot fires.

Although lightning fires were usually small, they had a pronounced effect on the vegetation because of their high frequencies. Recent lightning strikes that were observed produced ground fires that consumed forest litter, thus creating pioneer soil conditions. Surface fires temporarily reduced existing tree reproduction and shrubs, possibly enabling the overstory trees to obtain more of the limited moisture (Billings, 1950). Meyer (1931) found that when understory competition was reduced by fire, released growth of overstory trees occurred within two years. Lightning strikes and fires were also observed to eliminate over-mature trees and insect or disease-infected trees. After each local fire, *P. jeffreyi* appears to replace itself, since it is apparently the best adapted species to re-colonize the fire-altered community (Biswell, 1963). *Abies* cannot return immediately because of its more mesophytic requirements. Fire on Mt. Pinos has produced a mosaic of small even-aged groups of trees or blocks of vegetation at the same successional stage (Cooper, 1961). The *P. jeffreyi* forest above 6000 ft. elevation has existed for centuries under continual bombardment from lightning and a subsequent patchwork of small fires.

With fire protection and the presently effective lightning fire suppression, local pockets of the forest are tending to become overstocked with spindly, sapling-size *P. jeffreyi*. A denser growth of saplings may produce stunting because of competition, and the saplings may hamper overstory tree growth by competing directly with the trees for moisture (Arnold, 1963). This could reduce stand vigor and the trees might become susceptible to insects and disease. The increase in understory stocking may ultimately lead to the destruction of the entire forest by contributing to widespread crown fires (Leopold *et al.*, 1963).

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## NOTES AND NEWS

THE OCCURRENCE OF *HEMITOMES CONGESTUM* IN THE SOUTHERN SIERRA NEVADA, CALIFORNIA—*Hemitomes congestum* Gray has recently been collected from Sequoia National Park and Mineral King Game Refuge in Tulare Co. This, the second record of the species in the Sierra Nevada, is a range extension of approximately 250 miles south from an early collection (*E. V. Schurr*, May 18, 1934, UC) at Camptonville in Yuba Co.

We first collected this species during the summer of 1966 (*Rice & Merryman 478*, CAS, DAV) between Evelyn Lake and Hockett Meadow. Additional collections were made in Sept., 1967, when two fruiting specimens were obtained from widely separated locations along the Mineral King—Hockett Meadow trail (*Rice 642a*, DAV; *Rice 642b*, DAV). Several other small colonies of *Hemitomes* from which no specimens were taken were observed in the area.

*Hemitomes congestum* is best known from the redwood forest in northern California where it grows on humus below 2500 feet. Our collections are especially interesting in that they were made between 8,400 and 8,700 feet on the relatively dry, open floor of a red fir forest on soils of granitic origin. There was very little litter and few herbaceous plants in the vicinity of the colonies.—BARBARA RICE, University of California, Davis.



# TAXONOMY, VARIATION, AND CHOROLOGY OF THREE CHROMOSOME RACES OF THE CALAMAGROSTIS CANADENSIS COMPLEX IN ALASKA

WM. W. MITCHELL

*Calamagrostis canadensis* (Michx.) Nutt. (Bluejoint) is one of the most important native grasses in the herbland economy of subarctic Alaska. It predominates in tall grasslands of southcentral and southwestern Alaska and is prominent in other mixed forb and grass communities. *Calamagrostis canadensis* demonstrates a wide ecological amplitude, occurring in lowland wet areas to windswept alpine ridges and in all major geographic regions from southeastern to arctic Alaska. It is rare or infrequent, however, in the Arctic (Wiggins and Thomas, 1962; Johnson, et al., 1966) and absent from the high Arctic (Porsild, 1957). The grass, considered in the wide sense, is circumpolar in distribution (Hultén, 1962).

Taxonomic treatments of this complex generally recognize two (Hultén, 1942; Porsild, 1951; Gjaerovoll, 1958; Anderson, 1959) or three (Stebbins, 1930; Raup, 1947) subspecific entities in the far Northwest with some disagreement about nomenclature. Löve and Löve (1965) have attempted to resolve the differences and relate the taxonomy of the group to reported findings of two principal cytological races,  $2n = 56$  and  $2n = 42$ , in North America. They concluded that *C. canadensis* s. str. should be restricted to the hexaploid level and that the octoploids should be referred to *C. langsdorfii* (Link) Trin. Later these authors (Löve and Löve, 1966), concurring with Tzvelev (1965), combined *C. langsdorfii* with *C. purpurea* (Trin.) Trin. of Eurasia, it therefore becoming *C. purpurea* ssp. *langsdorfii* (Link) Tzvelev. But this treatment did not encompass the tetraploids ( $2n = 28$ ) reported in eastern Asia as *C. langsdorfii* (Tateoka, 1954; 1967; Sokolovskaja, 1963). Löve and Löve (1965) considered these tetraploids to be *C. angustifolia* Kom.

However, the report of tetraploid *C. langsdorfii* merits further consideration. Seed for the type material of *C. langsdorfii* presumably originated on Kamchatka Peninsula in eastern Asia. Subalpine meadows in which bluejoint is an important component occur there that are very similar to those in portions of southwestern Alaska (Hultén, 1937a). My investigations reveal that Alaskan bluejoint is a complex consisting of three euploid races, the most abundant being tetraploid, new to the records for North America. These findings justify a taxonomic review of the group. Further, the chorology of the three Alaskan races lends itself to some interesting interpretations regarding the glacial history of the region and its effects on plant survival and migrations.

## METHODS

Chromosome counts were obtained on root tips taken from vegetative material collected in the field and grown in the greenhouse. The tips

were soaked in ice water for 16–20 hours, fixed in 3:1 alcohol and glacial acetic acid solution, hydrolyzed in 1N HCl at c. 60°C for 8–12 minutes, and stained in Feulgen prior to squashing in aceto-carmine. A few counts were made on pollen mother cells collected in the field, fixed in 3:1 solution and smeared in aceto-carmine.

Specimens were analyzed morphologically for the following characters: 1, length of inflorescence; 2, length of spikelet; 3, length of lemma; 4, ratio: point of awn attachment measured from base of lemma/length of lemma; 5, length by which awn exceeds lemma; 6, length of an anther; 7, length of ligule; and 8, width of leaf.

## RESULTS AND DISCUSSION

**CYTOLOGY and DISTRIBUTION.** Tetraploid and hexaploid races of blue-joint dominate in Alaska. Octoploids appear to be rare except in particular circumstances. Hybrids between the races also are rare, only a single presumed hybrid ( $2n = 49$ ) having been found.

Counts were obtained on the following Alaskan specimens (mainly AES) with all but one of the collections made by the author.

**$2n = 28$ :** W and SW Alaska: Galena, 727A33, 727A38; Bishop Rock, W of Galena, 727A4; Poorman, S of Ruby, 621D44, 621D30, 621D31; Lake Minchumina, N of McKinley Park, 619D29, 619D30, 619D31, 619D32; Farewell, SE of McGrath, 619D16; Medfra, E of McGrath, 621D39, 621D41; McGrath, 622D2; Takotna, W of McGrath, 621D5; Colorado Creek, NW of McGrath, 621D6, 621D7, 621D8; Flat, E of Holy Cross, 621D20, 621D21, 621D22, 621D23, 621D24; Stony River, on Kuskokwim R., 620D1; Sleetmute, on Kuskokwim R., 620D15; Red Devil, NW of Sleetmute, 620D9; Aniak, lower Kuskokwim R., 620D53; Anvik, on Yukon R., 620D27; St. Michael, S coast of Norton Sound, 620D24, 620D44, 620D46; Stebbins, W of St. Michael, 620D32; Togiak W of Dillingham, 822D2, 822D6; Dillingham, 822D14; Ekwok, NE of Dillingham, 822D15, 822D17, 822D18; King Salmon, 823D7, 823D10, 823D29; Iliamna, 823D17, 823D19.

Cook Inlet drainage region: meadow N of Homer, 712C26; subalpine grassland E of Anchor Point, 521B1, 521B2, 521B3; between Kenai and Soldotna, 712C15; Funny River road E of Soldotna, 105C1, 105C4; Alyeska, ski lodge SE of Anchorage, 86D1; cleared areas vicinity of Palmer, 526A1, 526A2, 423B1, 423B2, 816B2, 816B3, 816B4; Little Susitna Valley N of Palmer, 715B1, 715B2, 98D9, 927D2; homestead W of Wasilla 921C5; Skwentna airstrip, Susitna Valley, 619D24, 619D25; Chelatna Lake W of Talkeetna, 622D7, 622D11, 622D14; Peters Creek W of Talkeetna, 71A25, 71A26; Montana Creek S of Talkeetna, 72A10.

Gulkana and Copper River basin: Mile 15.5 Tok Hwy. N of Gakona, 817D12; N of Paxson, 922C6; Tangle R. campground W of Paxson, 926C6; along Denali Hwy. about 54 miles NW of Paxson, 723B1.

Tanana River drainage: Mile 17 Taylor Hwy., 818D48, 818D34; Mile 4 Taylor Hwy., 818D9; Alaska Hwy. near Tok Junction 818D3; Mile 115 Tok Hwy. S of Tok Junction 818D42; Mile 295 Richardson Hwy. NW of Delta Junction, 923C2; Mile 310 Richardson Hwy., 923C3; Mile 312 Richardson Hwy., 710A1; Fairbanks, 730A1; Mile 87 Steese Hwy. N of Fairbanks, 924C1.

**$2n = 42$ :** Western and southwestern Alaska: McGrath, 622D4; Dillingham, 822D11.

Cook Inlet drainage region, alpine tundra: Lazy Mt. E of Palmer, 725D10; Eklutna Valley SW of Palmer, 728D17, 728D16; Eagle R. valley SW of Palmer, 97D9.

Gulkana and Copper River Basin: Eureka Lodge area, Glenn Hwy. SW of Glennallen, alpine tundra, *819D10*; Mendeltna Creek, SW of Glennallen, *82C3*; Mile 180 W of Glennallen, *82C19*, *82C20*, *817D4*, *817D8*; Mile 181.5 W of Glennallen, *719B16*; along Richardson Hwy. 1 mile S of junction with Glenn Hwy., *731B7*; Copper Center, *731B10*, *819D1*, *819D2*, *819D6*; McCarthy, *815C21*; along road between McCarthy and Kennecott, *815C7*; Tangle R. campground W of Paxson, *926C5*; 5 mile N of Paxson, *624B12*, *922C5*, *922C7*, *922C8*; Mile 45 Tok Hwy. N of Gakona, *817D16*; Mile 68.5 Tok Hwy., *817D26*; Slana, near junction Tok Hwy. and Slana cutoff, *Dickson & Taylor* Aug. 10, 1961.

Tanana and Yukon R. drainages: Mile 30 Taylor Hwy. N of Tok Junction., *818D23*; Mile 312.7 Richardson Hwy. NW of Delta Junction, *925C5*; Fairbanks, near international airport, *818B19*, *818B21*; Manley Hot Springs, *626B12*; Birch Creek S of Circle along Steese Hwy., *924C11*; 1 mile S of Circle, *924C16*; Circle, terminus of Steese Hwy., *924C22*.

**2n = 49:** Copper Center Lodge area Copper River Valley, *83C11*.

**2n = 56:** Western Alaska: Bishop Rock, along Yukon R. W of Galena, *727A3*, *727A21*.

Upper Cook Inlet region, alpine tundra, southcentral Alaska: Lazy Mt. E of Palmer, *725D2*, *725D4*, *725D5*, *725D18*, *725D20*; Little Susitna Valley N of Palmer, *98D3*.

Upper Copper River Drainage: Mile 68.5 Tok Hwy. S of Mentasta Pass, *817D27*.

The tetraploid race predominates in Alaska's southwestern and south-central coastal regions and probably northward along the coast at least to the Seward Peninsula (fig. 1). The extent of its occurrence beyond the Tanana River drainage in the drier Interior of Alaska is not known, but only hexaploids and octoploids have been reported so far across Canada (Bowden, 1960; Löve and Ritchie, 1966; Nygren, 1954). Hexaploids are present in the upper Yukon River drainage of Alaska and may dominate there, but further sampling is needed. Both hexaploids and tetraploids are well represented in the Tanana Valley from the Canadian border to Fairbanks and in the relatively dry Copper River and upper Susitna River drainages south of the Alaska Range. A few hexaploids were found in alpine landscapes of the coastal southcentral area. The octoploid has been collected only at four locations — in westcentral Alaska, in eastcentral interior, and at two locations on alpine slopes of the upper Cook Inlet area. Occurrence of a possible hybrid between hexaploid and octoploid races at Copper Center implies the presence of octoploids there. The Arctic, Aleutian Islands, and southeastern panhandle have not been investigated cytologically as yet.

Of particular interest is the chorology of the three races in the upper Cook Inlet area. Dense stands of tall-growing bluejoint occur on burned-over timberland and in the subalpine zone above timberline throughout coastal southcentral Alaska. The bluejoint of these stands is tetraploid as determined by a large number of counts. However, octoploids and hexaploids were found in the alpine zone of the Chugach and Talkeetna Mountains near Palmer. Octoploids and hexaploids appear restricted to alpine sites in this area while tetraploids clearly have the advantage in occupying disturbances and dominating certain herbland communities at lower altitudes.



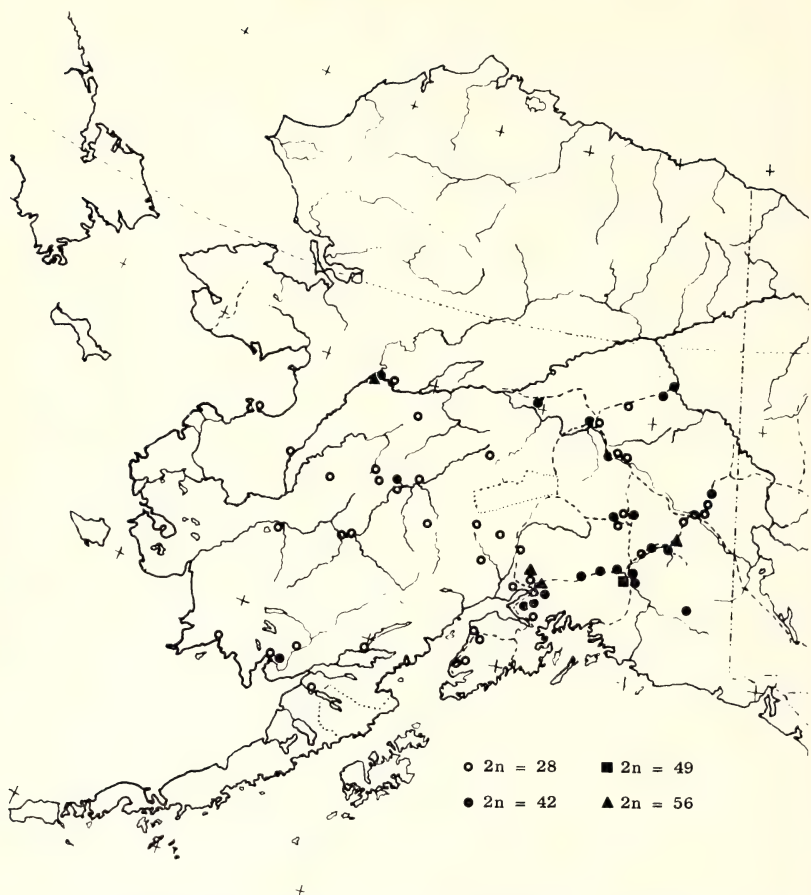


FIG. 1. Distribution of specimens of the *Calamagrostis canadensis* complex in Alaska on which chromosome counts were obtained.

**MORPHOLOGY.** *Calamagrostis canadensis* is distinguished by its relatively stout rhizomes; generally tall robust culms, occasionally branched, with 3–6 nodes; relatively long, wide leaves; more or less open panicle; glumes with scabrous hairs throughout, often tending to diverge when empty; and thin membranous lemma with delicate awn and long, generally widely spreading callous hairs.

Representative plants of the different races are shown in Fig. 2. Inflorescence form varies a great deal within each race (fig. 3), some of the variation obviously being related to environmental conditions. Clonal material collected at Galena, when grown in a fertilized experimental garden at Palmer, differed tremendously from its depauperate counterpart collected in the field (fig. 3, e and f), as did to a lesser extent material from the vicinity of the Fairbanks International Airport (fig. 3, n and o). Some of these abnormally depauperate individuals resemble *C.*

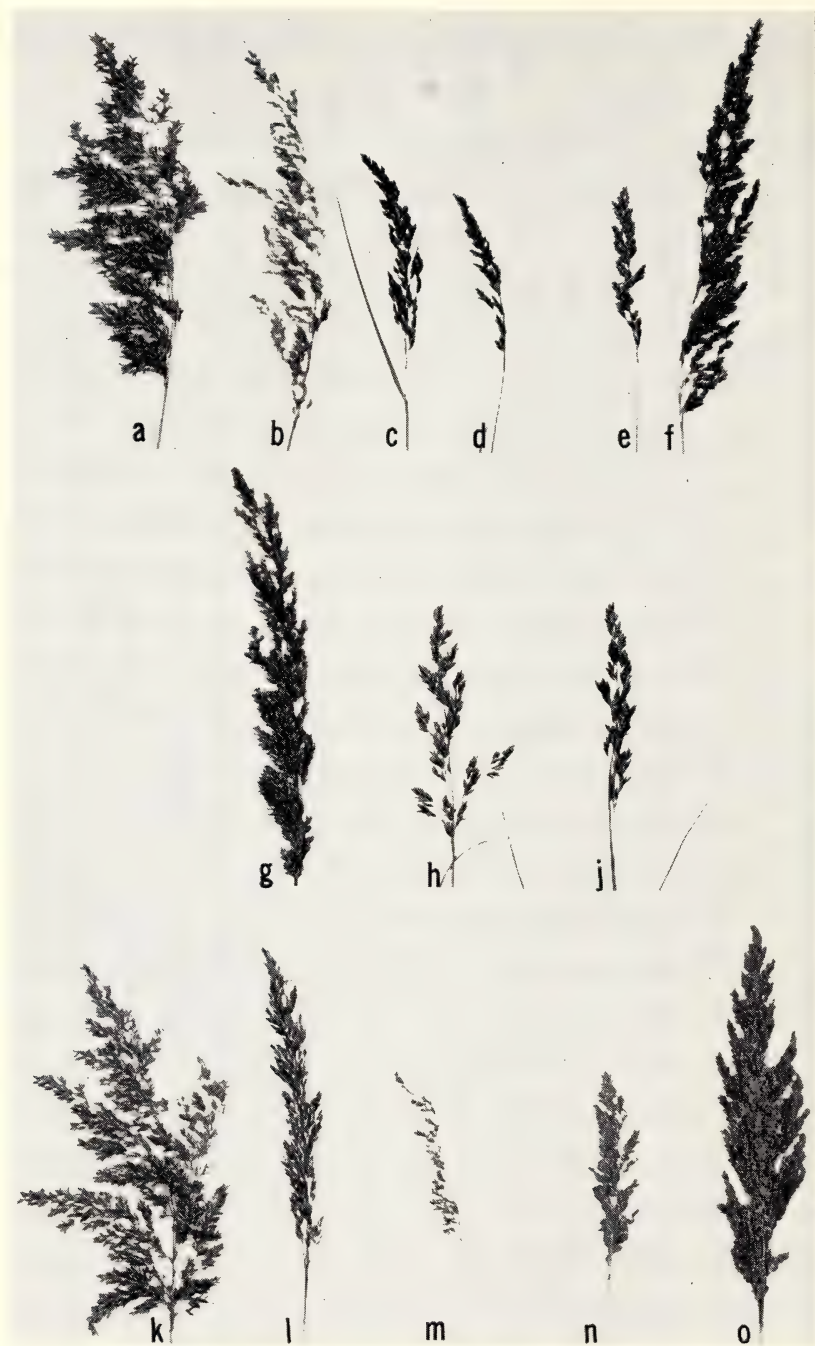




FIG. 2. Representative vouchers of four chromosome races of *Calamagrostis canadensis* complex in Alaska.

*angustifolia* in Komarov (1934), but the spikelet characteristics are definitely those of *C. canadensis*. Circumstances appear to require their assignment to *C. canadensis*.

Other workers have had varying success in separating the different



chromosome races. Bowden (1960) concluded that his hexaploid and octoploid plants of northern Canada could not be separated morphologically. Löve and Löve (1965), on the other hand, found the octoploids in the alpine zone of Mt. Washington, New Hampshire, clearly distinguishable from the hexaploids lower on the mountain. Similarly, in the current study spikelet measurements of the octoploids from alpine regions near Palmer were distinctly longer than the bulk of the tetraploids and the few hexaploids found in the same area.

No good qualitative differences were found, however, for distinguishing the races and all overlapped in their measurements (fig. 4 and table 1). Overlapping between the tetraploids and hexaploids is so great as to preclude considering separating these two. The apparent separation of the octoploid is confounded by the occurrence of an ecotypic trend in sizes of plant parts. Those in the interior tend to have smaller parts than those in the coastal regions; for instance, spikelet length of 14 tetraploids of the Cook Inlet region averaged 4.13 mm compared with 3.60 mm for 15 tetraploids of the more northern interior. The 3 octoploid specimens from the interior averaged 4.6 mm, 3.5 mm, and 2.0 mm for spikelet-, lemma-, and anther-length, respectively. Except for anther length these values are within a standard deviation of the average values determined for the hexaploids (table 1). A number of plants analyzed from the Southeast and the Aleutian Islands, cytology unknown, had particularly long spikelets, those from the Aleutian Islands averaging well above the measurements obtained on the octoploid vouchers. A tetraploid composition is indicated for the Aleutian Island population (fig. 1), although it may be otherwise. Thus, any effort to differentiate the cytological races morphologically must take into consideration geographic occurrence.

**TAXONOMIC DISPOSITION.** There is an obvious contradiction in the various interpretations of the *langsдорffii* type. Hultén (1942; 1962) differentiates ssp. *langsдорffii* from ssp. *canadensis* by its longer spikelets, larger panicle, broader leaves, and taller growth. He considers it represented across North America but in Alaska more coastal in its occurrence than ssp. *canadensis*. Löve and Löve (1965; 1966), and others, concur with Hultén in associating *langsдорffii* with the more robust growth habit; further, these authors assign it to the octoploid level.

It appears, however, that the tetraploid material of eastern Asia and that of Alaska are conspecific and relate to the type material of *langsдорffii*. Moreover, the tetraploids as a rule have smaller spikelet measurements

FIG. 3. Variation in inflorescence form and size in the different races of *Calamagrostis canadensis* in Alaska:

$2n = 28$ : a, *Mitchell 922C8*; b, *921C5*; c, *712C15*; d, *96D1*; e, *727A38*; and f, clonal material of *727A38* grown in experimental garden at Palmer.

$2n = 56$ : g, *727A21*; h, *98D3*; and j, *725D20*.

$2n = 42$ : k, *292C7*; l, *82C20*; m, *922C5*; n, *818B21*; and o, clonal material of *818B21* grown in experimental garden at Palmer.

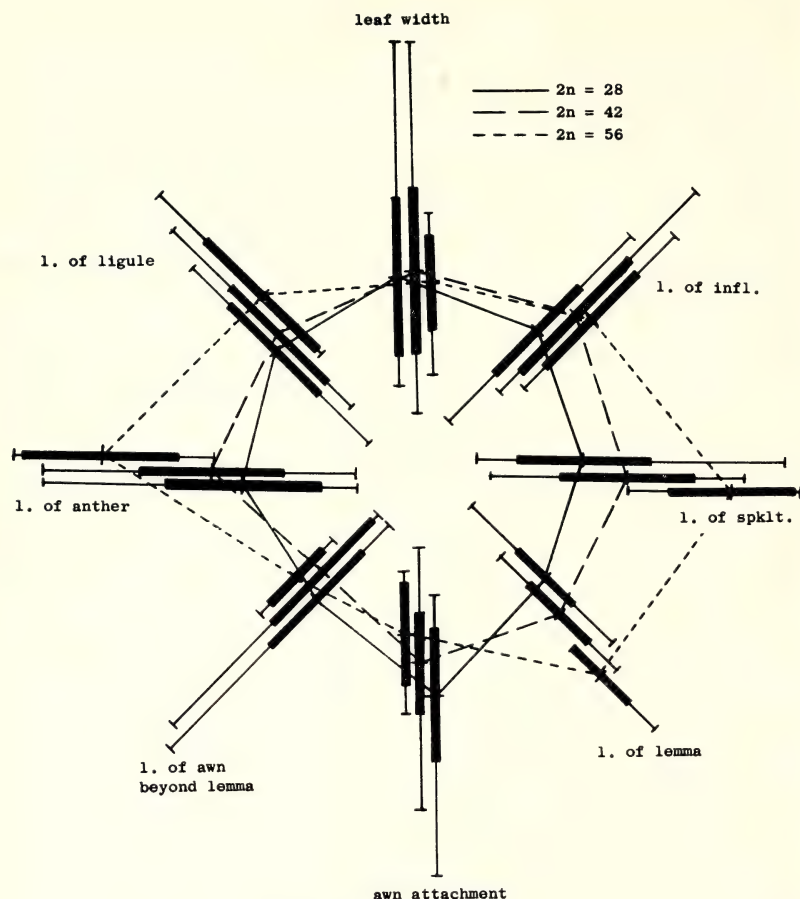


FIG. 4. Polygonal representation of morphological analysis of three chromosome races of *Calamagrostis canadensis* in Alaska based on information contained in Table 1. Total range, mean, and range of two standard deviations represented for each character. Means are interconnected by lines for each race.

than the octoploids and apparently are restricted to eastern Asia, Alaska, and possibly the Yukon Territory and coastal regions to the south of Alaska.

Biologically there may be reason to recognize all three races as specific entities. But morphological considerations preclude the separation of the tetraploid and hexaploid races. In some local areas floral parts may serve, to a certain extent, to separate the octoploid from the other two races. This is much less certain, however, as collections from different areas become involved. In view of the small sample of octoploids so far considered I believe formal recognition of the three races should be deferred until their ranges and morphological distinctions are better delineated.



TABLE I. QUANTITATIVE ANALYSIS OF THREE CHROMOSOME RACES OF THE CALAMAGROSTIS CANADENSIS COMPLEX.

Number of specimens of each race analyzed: 37 of  $2n = 28$ , 33 of  $2n = 42$ , and 8 of  $2n = 56$ .

Character	Chromosome Race, $2n =$	Range	Mean	S.D.	Range of Two S.D.
Leaf width, mm	28	3.0 - 9.0	4.9	1.39	3.5 - 6.3
	42	2.5 - 8.0	5.0	1.42	3.6 - 6.4
	56	3.2 - 6.0	4.8	.82	4.0 - 5.6
Length of inflorescence, cm	28	6.0 - 18.0	11.9	2.83	9.1 - 14.7
	42	8.5 - 21.5	13.5	3.63	9.9 - 17.1
	56	9.5 - 19.5	14.0	3.14	10.9 - 17.1
Length of spikelet mm	28	3.0 - 5.7	3.9	.56	3.3 - 4.5
	42	3.1 - 5.3	4.3	.59	3.7 - 4.9
	56	4.3 - 5.8	5.2	.55	4.7 - 5.8
Length of lemma, mm	28	2.0 - 3.7	2.9	.34	2.6 - 3.2
	42	2.5 - 3.9	3.2	.36	2.8 - 3.6
	56	3.5 - 4.5	3.8	.36	3.5 - 4.2
Awn attachment/length of lemma	28	.16 - .88	.41	.17	.24 - .58
	42	.03 - .71	.33	.13	.20 - .46
	56	.09 - .47	.26	.13	.13 - .39
Length by which awn exceeds lemma, mm	28	0.0 - 1.8	.60	.38	.22 - .98
	42	0.0 - 1.7	.45	.40	.05 - .85
	56	0.3 - 0.9	.60	.24	.36 - 8.4
Length of anthers, mm	28	1.1 - 2.2	1.5	.27	1.2 - 1.8
	42	1.1 - 2.2	1.6	.24	1.4 - 1.8
	56	1.6 - 2.3	2.0	.27	1.7 - 2.3
Length of ligule mm	28	3.5 - 10.0	6.9	1.61	5.3 - 8.5
	42	4.5 - 11.0	7.2	1.79	5.4 - 9.0
	56	6.0 - 12.0	8.2	2.10	6.1 - 10.3

PHYTOGEOGRAPHIC CONSIDERATIONS. Theories on plant survival and migration in glacial and post glacial times propose the revegetation of glaciated southcentral Alaska by plants migrating from the unglaciated interior and the western coastal and exposed Bering Strait region (Hultén, 1937; Heusser, 1967). Heusser also has proposed the survival of plants in small refugia along the southern coast of Alaska. Migration of the octoploids from the interior to their current position in the Cook Inlet area would require their traversing expanses that today are occupied by the obviously more aggressive hexaploids and tetraploids. Some evidence of a migrational history was found in the occurrence of an octoploid plant (*Mitchell 817D27*) on deglaciated terrain at the edge of a ponded kettle near the Mentasta Pass of the Alaska Range. A hexaploid (*Mitchell 817D26*) was found at the same site.

Certainly with a more comprehensive effort the known distribution of the octoploid would become less disjunct than represented in Fig. 1, but it obviously is rare to infrequent through much of Alaska. Octoploid bluejoint would appear to fit Hultén's (1937b, p. 20) description of a taxon losing its variability through periodic reductions by glacial ad-

vances, thereby becoming rigid and unable to spread. I think it unlikely that the current distribution of the octoploid represents a range reduction following a postglacial migration from interior Alaska. Rather, its presence in the alpine regions of the upper Cook Inlet area appears to be that of a relic surviving a more extensive distribution attained prior to the late glacial period. (Also see Löve (1959) concerning the origin and distribution of high polyploids in the pre-Pleistocene and early Pleistocene periods.) I hold a similar view for the octoploids found in west-central Alaska on Bishop Rock, a conspicuous knob in the flats of the Yukon River west of Galena, where a possible relic brome also was discovered (Wilton, 1965; Mitchell and Wilton, 1966). Bishop Rock and other heights in this unglaciated area contain some relatively dry, shaly bluffs that are not subject to the disturbances of the adjacent lowlands and which support plants that do not occur in the more moist, wooded uplands of the area. These are suitable sites for the persistence of relics adapted to their particular conditions.

In the upper Cook Inlet area tall herbaceous and shrubby subalpine communities extend above timberline to the limits of well marked glacial morainic features (Mitchell, 1968a). Karlstrom (1964) cited 2,000 ft. as the elevation of the lateral moraines of the late Wisconsin ice advances on the upper Kenai Peninsula. Moraines occur at about 2,800 ft. on the Chugach and Talkeetna Mountains north of Anchorage. Well developed alpine communities obtain above these morainic features to over 5,000 ft. on the less precipitous mountain slopes. I think extensive areas of these alpine reaches very likely served as refugia for plants during the last ice advances. Finding hexaploid and octoploid races only on what appear to be unglaciated alpine sites in a region where the tetraploid is eminently successful lends support to the theory. Further evidence was found in the occurrence of a tetraploid colony (*Mitchell 927D2*) on an alpine site, about 3,700 ft., that obviously had been glaciated. This suggests a cytological distinction between populations in the upper Cook Inlet region in relation to duration, those of relatively recent origin on glaciated terrain being tetraploid and those of longer duration on unglaciated terrain being hexaploid or octoploid. This theme concerning the existence of nunataks in southcentral Alaska (Mitchell, 1968b) will be developed more thoroughly in a future article.

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### NEW RECORDS OF MYXOMYCETES FROM CALIFORNIA. III.

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The number of species of slime molds reported to date in California is 180. Ten new records are listed in this paper. This brings the total number of Myxomycetes reported in print as occurring in California to 190 species. All collections cited here (MICH) are those of the senior author. The names of the organisms are those accepted by Martin (1949) and the numbers are those of the senior author. This investigation was supported by National Science Foundation Grant GB-5799.

We wish to express our appreciation to Travis E. Brooks of the University of Kansas for verifying the identifications of some of the more difficult collections.

#### LICEACEAE

*Licea biforis* Morgan. On decaying bark, 2 miles west of Child's Meadows, 4,400 feet elevation, Tehama Co., 2747, Apr. 16, 1966. This species is distinctive in that it is the only member of the genus with sporangia which are repent, fusiform and open by a single longitudinal slit. Most descriptions give the color as yellow-brown, in this collection the sporangia are black and the depressed longitudinal slit is light tan. Its favorite habitat is stated as being the inner layers of dead bark. The fruiting bodies in this collection are on the outer surface of coniferous bark. This taxon has a very scattered distribution pattern, being known in this country only as far west as Kansas. However, it is probably fairly common. Its rareness is undoubtedly due to its inconspicuousness and may occur throughout the United States.

*Licea tenera* Jahn. On sheep dung, 3 miles south of Chico, Butte Co., 6238, May, 1967, developed in a damp chamber. This species is mainly known from moist chamber developments. The type collection consists of approximately a dozen sporangia. The California material fits the type material in that the sporangia are sessile, globose, orange and inde-



hiscent. It differs from the type, however, in size and in spore characteristics. The type sporangia are 0.4–0.5 mm in diameter while the California material averages about 0.2 mm in diameter. The spores in the type collection have short spines and a pale area on one side, the California material has spores which are smooth and lack the pale area. In regards to the size of the sporangia this collection resembles two collections from Kansas which are 0.1 mm in diameter. The Kansas material, however, consists of sporangia which are thickly coated with refuse material which makes them appear black. Because of these discrepancies the exact taxonomic standing of this taxon is in doubt. It is extremely rare, being known from only a few collections throughout the United States. It has, however, been reported from Oregon.

#### CRIBRARIACEAE

*Cribraria splendens* (Schrad.) Pers. Three collections, all on decaying coniferous bark, MacKerricher Beach State Park, Mendocino Co., 4800, 4814, 4828, Jan. 25, 1967. These collections are both abundant and fit the published descriptions perfectly. This species is distinct in the genus because it is one of the few members that lacks a distinct cup. The cup is replaced by firm ribs, usually 8–15, which radiate from the tip of the stalk. Occasionally these ribs are connected by a delicate, hyaline membrane. It is an uncommon taxon, but is known from widely scattered regions across the United States, like most species in the genus, it is found mainly in coniferous forests.

#### DIANEMACEAE

*Dianema andersonii* Morgan. Two collections, both on decaying coniferous wood, Well's Cabin Campground, 6,300 feet elevation, Tehama Co., 1586, 1613. This is one of the true snowline Myxomycetes, i.e., it fruits only under or near the melting snow and is exposed when the snow melts back. This species and *D. harveyi* Rex are very difficult to separate. Traditionally they are distinguished as follows: *D. andersonii* is sporangiate, sessile or substipitate, brown and has spores which are pinkish by transmitted light, warted and 10–12  $\mu$  in diameter. *Dianema harveyi* is sporangiate to plasmodiocarpous, always sessile, dull red or brown, and the spores are pale yellowish by transmitted light, spiny and 8–10  $\mu$  in diameter. As can be seen, these differences are slight and it is possible that both of these species simply represent different forms of the same taxon. The major problem is that they are both known from just a few collections and until sufficient material is available, the exact taxonomic ranking of these species will not be resolved. *Dianema andersonii* has been reported in the Western Hemisphere only from British Columbia and Washington.

#### STEMONITACEAE

*Amaurochaete fuliginosa* (Sow.) Macbr. Three collections, all on decaying bark, Woodson Bridge State Park, Tehama Co., 6041, 6060, 6062.

This aethaloid member of the Stemonitaceae is characterized by having spinulose spores 12–15  $\mu$  in diameter and a capillitium that is rigid and irregular. It was found in abundance on the bark of a large oak, *Quercus lobata* Neé, that was recently felled by a storm. Most of the aethalia are small for this species, being only 2–3 cm in diameter. Some descriptions state that the hypothallus is a slender stalk-like strand. In the California collections the hypothalli are extensive, procumbent and attached to the substrate along their entire lower surfaces. It is an uncommon taxon, being reported from scattered localities across the United States and on the west coast from Washington.

*Comatricha rubens* List. Three collections, two from Lower Bidwell Park, Chico, Butte Co., 2323 on decaying bark, Jan. 2, 1966, 4046 on a decaying leaf, Dec. 9, 1966, and one on decaying *Eucalyptus* bark, Point Reyes National Seashore, Marin Co., 5164, Jan. 29, 1967. This species is distinct in the genus by having light-colored lilaceous or ferruginous spores and sporangia with a distinct basal cup which is attached to the capillitium. It is extremely common in California and on all types of substrates. We have found it on dead wood, dead leaves, dead bark and on various other types of plant debris. For the sake of brevity, we only listed three collections, but we have made over 50 collections. It is not a rare taxon, being known from many scattered localities across the United States.

#### PHYSARACEAE

*Badhamia affinis* Rost. Two collections, both on decayed leaves, Butte Creek and Skyway, Butte Co., 3960, 3982, Nov. 25, 1966. The sporangia are white, rugulose, rounded to distinctly flattened. Both collections contain sporangia which are either stalked or sessile. When stalked, the stipe is very short, about 1 mm in height, black, and furrowed. The only atypical characteristic about these two collections is the habitat. Both Hagelstein (1944) and Martin (1949) give the substrate as bark, either living or dead. Thus, the occurrence of this species on decayed leaves appears to be unusual. This species is not rare. It is cosmopolitan and is known from many collections in the United States.

*Badhamia ainoae* Yamashiro. Four collections, all on the bark of living oak trees, Moores Ranch, 12 miles south of Chico, Butte Co., 2331, Jan. 7, 1966, 2461, Feb. 6, 1966; Lower Bidwell Park, Chico, Butte Co., 2341, Jan. 8, 1966, 4389, Dec. 22, 1966. This species is unique in the genus in that the capillitium is represented by tubular calcareous columns, simple or forked, which extend from the base to the peridium. This is somewhat reminiscent of the tubes in *Didymium sturgsii* Hagelst. The fruiting bodies are sessile, pulvinate sporangia or short plasmodiocarps and are widely scattered. They vary from brownish, when lime is lacking, to white in color when the peridium is covered with a thin calcareous crust. These collections mark the first reported occurrence of this species in the Western Hemisphere. Travis E. Brooks of the Uni-

versity of Kansas, Lawrence, Kansas has made several collections in the Eastern United States and all of them were also on the bark of living trees (personal communication). It is previously only known in print from Japan. It is apparently a very rare taxon, all known collections being on the bark of living trees. It is possible, however, that it may be much more common than its distribution would indicate. This could be due to the fact that very few collectors look for Myxomycetes on the bark of living trees.

*Badhamia dearnessii* Hagelst. Two collections, both found 12 miles south of Hamilton City, Glenn Co., Dec. 29, 1966, 4528 on plant debris and 4547 on decaying bark. Previously, this species was only known from a few collections in Quebec and Maine. It is distinct because it is the only species in the genus that has spores which are encircled by a pale band. All descriptions of this taxon state that the sporangia are sessile. In 4547 many of the sporangia are stalked. The stalks are short, 1–2 mm in length, and of a pale yellow color. The descriptions also indicate that the capillitium is a delicate network scantily charged with lime or nearly limeless and then appearing pale yellow. In both of the California collections the capillitium is robust, pure white, and densely filled with lime, there being no limeless threads whatsoever.

*Physarum gilkeyanum* H. C. Gilbert. On decayed leaf, along the Sacramento River, 1.7 miles south of Sacramento Road, Butte Co., 988, Dec. 14, 1964. The description of this species states that the sporangia are sessile, white, single-walled and covered with limy ridges which give the appearance of a reticulum. The California collection agrees with this description except that only a few of the sporangia have the limy reticulum. Since this is an extremely rare species, being known previously only from the type locality in Lebanon, Oregon, we do not believe that this slight discrepancy should be regarded as important enough to relegate the California material to a different taxon. Hagelstein (1944) believed that this taxon was probably a sessile form of *Physarum mutabile* (Rost.) List. We do not concur with this interpretation. We have made several collections of *P. mutabile* in California and all of the collections contain sporangia which are stalked and have a large cylindrical columella, which almost attains the apex of the sporangium. Some of the sporangia of *P. gilkeyanum* have a slight aggregation of lime knots at the base of the sporangia which slightly resembles a pseudocolumella. However, they do not remotely approach the large cylindrical columella of *P. mutabile*. Thus, we believe that these two species are distinct from one another and are not synonymous.

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CHROMOSOME COUNTS IN SECTION SIMIOLUS OF THE  
GENUS MIMULUS (SCROPHULARIACEAE). VIII.  
CHROMOSOMAL HOMOLOGIES OF *M. GLABRATUS*  
AND ITS ALLIED SPECIES AND VARIETIES.

M. M. MIA and ROBERT K. VICKERY, JR.

The purpose of this study is to extend our analysis of the chromosomal homologies of the *Mimulus glabratus* complex and its allied species and varieties previously initiated by Mukherjee and Vickery (1962) in the course of their investigation of the *M. guttatus* complex. Essentially the same cytological methods and crossing techniques were employed as before (Vickery, et al, 1968).

The *M. glabratus* complex was represented by cultures of 10 populations. One was of *M. pilosiusculus* HBK., a near relative of *M. glabratus* HBK., and the others were of three of the varieties of *M. glabratus*, *M. glabratus* var. *utahensis* Pennell, *M. glabratus* var. *fremontii* (Benth.) Grant, and *M. glabratus* var. *parviflorus* (Lindl.) Grant (table 1). The populations represent the diploid, tetraploid, and hexaploid chromosome levels of the complex,  $n = 15$ ,  $n = 30$ , and  $n = 45$  respectively. They also include representatives of two aneuploid levels,  $n = 14$  and  $n = 46$ .

For comparisons, cultures of eight additional populations, representing the three other main complexes of species in section *Simiolus* were also included in the investigation. The *M. guttatus* complex was represented by diploid,  $n = 14$ , and tetraploid,  $n = 28$  populations of *M. guttatus* DC. and by an aneuploid,  $n = 13$ , population of *M. nasutus* Greene. The *M. luteus* complex was represented by two tetraploid,  $n = 32$ , populations of *M. luteus* L. The *M. tilingii* complex was represented by a single diploid,  $n = 14$ , culture of *M. tilingii* Regel.

Cultures of the 18 selected populations were established in the greenhouse for the crossing program. Over a hundred interpopulation hybridizations were made. Only 48 of these produced hybrids and of these only 33 developed far enough to permit cytological study. The pairing behavior of the chromosomes was analyzed in an average of over 14 microspores for each different hybrid. Typical figures were recorded either photographically or with the aid of a camera lucida.

At the diploid,  $n = 14$  level, *M. glabratus* var. *utahensis* hybridized with the main species of section *Simiolus*, *M. guttatus*,  $n = 14$ , and the chromosomes of the resulting  $F_1$  hybrids revealed 6 to 14 bivalent associations (table 2). The observed minimum pairing of six suggests that only these six are fully homologous or so nearly so as to consistently synapse. The other eight chromosomes probably are not fully homologous as evidenced by their occasional failure to pair. On the average, 12 of the 14 chromosomes pair. The basic genome of 14 chromosomes apparently has become significantly differentiated in *M. glabratus* var. *utahensis* as compared to that of *M. guttatus*, representing the diverse *M. guttatus* complex.



TABLE 1. ORIGIN OF CULTURES USED IN THE CYTOGENETIC INVESTIGATION OF THE RELATIONSHIPS OF *MIMULUS GLABRATUS* AND ITS ALLIED SPECIES

*M. glabratus* var. *fremontii* (Benth.) Grant. 5063,  $n = 30$ , San Bernardino Co., Calif., ca. 1,200 ft, coll. - (UC); 5373,  $n = 30$ , Brewster Co., Texas, Cory 53,186 (UT).

*M. glabratus* var. *parviflorus* (Lindl.) Grant. 5041,  $n = 45$ , Illapel, Chile, 4,000 ft, U.S.D.A. Plant Introduction number 144,534 (UT); 6162,  $n = 46$ , Auetrihue, Argentina, Diem in 1959; 6163,  $n = 46$ , Lumaco-Puente del Cina, Chile, 600 ft, Kunkel, Nov. 29, 1958; 6184,  $n = 46$ , Tucuman, Argentina, 7,300 ft, de la Sota, Feb. 7, 1959.

*M. glabratus* var. *utahensis* Pennell. 5048,  $n = 14$ , Mono Co., Calif., 6,440 ft, Stebbins 714 (UT); 5747,  $n = 14$ , Mineral Co., Nev., 5,500 ft, J. Figg-Hoblein, July 4, 1950; 5265,  $n = 15$ , Wayne Co., Utah, 7,100 ft, Vickery 600.

*M. guttatus* DC. 6152,  $n = 28$ , Admiralty Island, Alaska, sea level to ca. 1,000 ft, G. L. Miller, Aug. 1958; 5052,  $n = 14$ , Contra Costa Co., Calif., 1,000 ft, Stebbins 703 (UT); 6250,  $n = 28$ , Yavapi Co., Arizona, 3,010 ft, Vickery 2593; 5017,  $n = 14$ , Inyo Co., Calif., 2,500 ft, Alexander and Kellogg 2844 (UC).

*M. luteus* L. 5042,  $n = 32$ , Illapel, Chile, 6,200 ft, U.S.D.A. Plant Introduction number 144,535 (UT); 6161,  $n = 32$ , Auetrihue, Argentina, Diem in 1959.

*M. asutus* Greene, 5327,  $n = 13$ , Tuolumne Co., Calif. 475 ft, Vickery 168 (UT).

*M. pilosiusculus* HBK. 5320,  $n = 46$ , Botanic Garden, Copenhagen, Denmark (wild in Argentina, Chile, and Peru), U.S.D.A. Plant Introduction number 181,130 (UT).

*M. tilingii* Regel. 5012,  $n = 14$ , Mono Co., Calif., 10,000 ft, Clausen 2075 (UT).

In the hybrids of *M. glabratus* var. *utahensis*  $\times$  *M. tilingii*, representing the *M. tilingii* complex of North American alpine species, the chromosomes exhibited 13 or 14 bivalent associations (table 2). Apparently the *glabratus* genome is almost fully homologous with the *tilingii* genome.

The fourth complex of section *Simiolus*, the *M. luteus* complex of South America, as represented by *M. luteus* ( $n = 32$ ) crossed readily with *M. glabratus* var. *utahensis* but produced sterile hybrids. The chromosomes of its  $F_1$  hybrids exhibited 6 to 14 bivalent associations (table 2). Apparently the first genome of *M. luteus* has about the same degree of homology with the *glabratus* genome as does the *guttatus* genome. The *guttatus* and *luteus* genomes are not identical but have differentiated from each other. The chromosomes of the  $F_1$  hybrids of *M. guttatus*  $\times$  *M. luteus* exhibit 11 to 13 bivalent associations (table 2) which suggests that they are about as different from each other as they each are from the chromosomes of the genome of *M. glabratus* var. *utahensis* but that different genes are involved in the differences.

At the tetraploid level, the *M. glabratus* complex was represented by two,  $n = 30$  cultures of *M. glabratus* var. *fremontii*. The two cultures, 5063 and 5373, are from widely different areas (table 1). The cultures cross readily in either direction, i.e.,  $5063 \times 5373$  or  $5373 \times 5063$ , but the  $F_1$  hybrids produced were sterile. Cytological examination of meiosis in these hybrids revealed predominantly 14 bivalent chromosome associations and only occasionally more pairs (table 2). The first genomes of

TABLE 2. PAIRING BEHAVIOR OF THE CHROMOSOMES IN THE  $F_1$  HYBRIDS OF *MIMULUS GLABRATUS* AND ITS RELATED SPECIES (FIGS. 1, 2).

Combinations, including reciprocals. (g. = <i>glabratus</i> )	♀ Parent culture number	n =	♂ Parent culture number	n =	Number of cells studied	Number of bivalents observed ×	range
<i>M. g. var. utahensis</i> ×	5747	14	5048	14	8	13	9-14
<i>M. g. var. utahensis</i>	5048	14	5265	15	14	13	11-14
	5747	14	5265	15	14	12	8-14
<i>M. g. var. utahensis</i> ×	5063	30	5747	14	16	14	9-16
<i>M. g. var. fremontii</i>	5373	30	5747	14	14	14	9-15
<i>M. g. var. utahensis</i> ×	6184	46	5747	14	14	14	14-15
<i>M. g. var. parviflorus</i>							
<i>M. g. var. utahensis</i> ×	5048	14	5052	14	11	13	11-14
<i>M. guttatus</i>	5747	14	5052	14	8	11	6-14
	6152	28	5048	14	14	14	all 14
<i>M. g. var. utahensis</i> ×	5747	14	5012	14	15	14	13-14
<i>M. tilingii</i>							
<i>M. g. var. utahensis</i> ×	5042	32	5048	14	12	13	6-14
<i>M. luteus</i>							
<i>M. g. var. fremontii</i> ×	5373	30	5063	30	20	15	14-22
<i>M. g. var. fremontii</i>							
<i>M. g. var. fremontii</i> ×	5041	45	5373	30	19	14	12-17
<i>M. g. var. parviflorus</i>	6184	46	5373	30	30	14	11-21
<i>M. g. var. fremontii</i> ×	5320	46	5373	30	30	16	14-20
<i>M. pilosiusculus</i>							
<i>M. g. var. fremontii</i> ×	5063	30	5052	14	7	12	2-15
<i>M. guttatus</i>	5373	30	5052	14	9	12	6-14
<i>M. g. var. parviflorus</i> ×	5041	45	6162	46	15	15	11-26
<i>M. g. var. parviflorus</i>	5041	45	6163	46	13	18	12-22
<i>M. g. var. parviflorus</i> ×	6162	46	6163	46	20	19	11-27
<i>M. pilosiusculus</i>	6184	46	5320	46	14	15	14-16
<i>M. g. var. parviflorus</i> ×	5041	45	5052	14	4	16	all 16
<i>M. guttatus</i>	6162	46	5052	14	6	13	12-14
	6163	46	5052	14	4	13	9-14
	6184	46	5052	14	24	14	12-14
<i>M. g. var. parviflorus</i> ×	6184	46	6161	32	16	15	11-19
<i>M. luteus</i>							
<i>M. pilosiusculus</i> ×	5320	46	5052	14	5	14	14-15
<i>M. guttatus</i>							
<i>M. guttatus</i> ×	6152	28	5052	14	39	13	5-14
<i>M. guttatus</i>	5052	14	6152	28	5	14	all 14
	6250	28	5052	14	31	13	9-14
<i>M. guttatus</i> ×	6152	28	5042	32	10	15	9-18
<i>M. luteus</i>	5017	14	5042	32	4	12	11-13
<i>M. guttatus</i> ×	5017	14	5327	13	1	13	13
<i>M. nasutus</i>							

these two populations appears to be almost fully homologous. The chromosomes of the second genomes exhibit modest homology under the most favorable conditions but the homologies are not sufficiently strong to cause consistent synapsis of any of the chromosomes of the second genomes. Apparently there are two distinctly different second genomes in *M.*

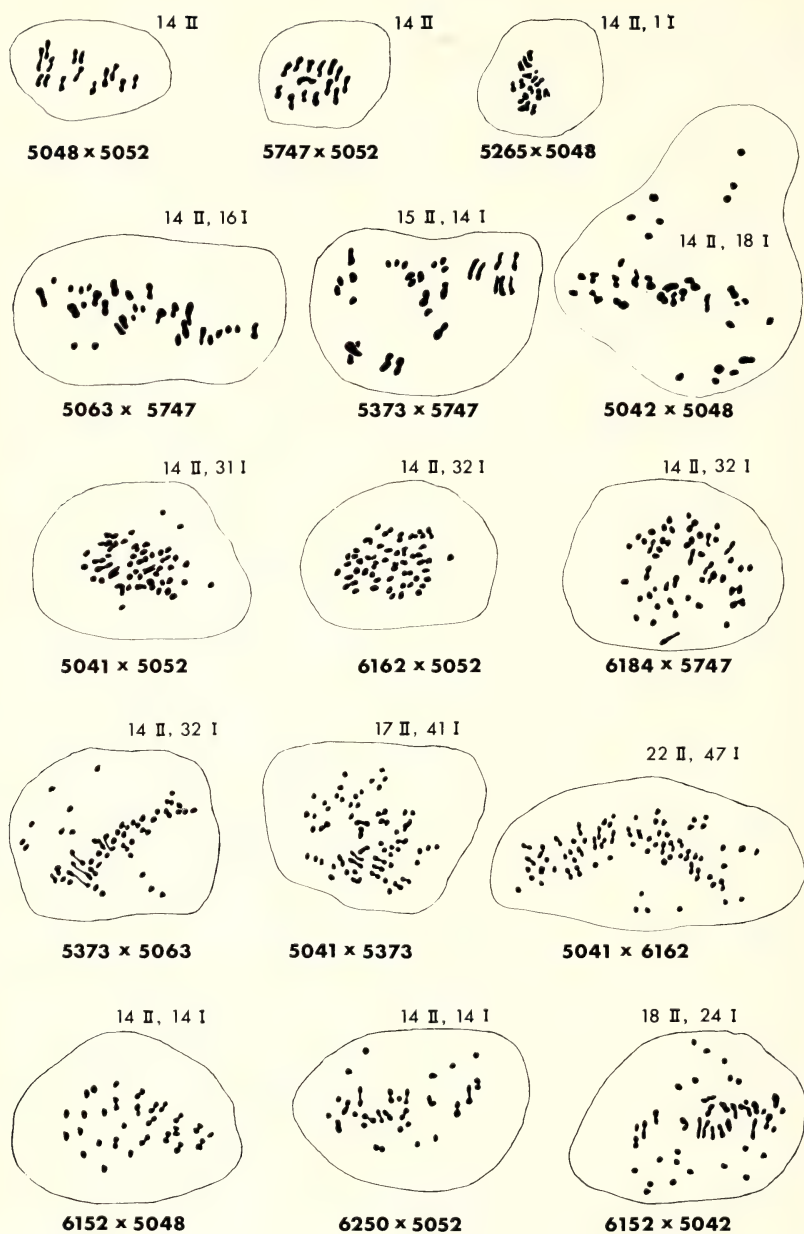
*glabratus* var. *fremontii*. The results bring into question the circumscription of this entity, but more material and study will be required to clarify the proper limits of *M. glabratus* var. *fremontii*. Unfortunately, tetraploid *M. glabratus* var. *fremontii* was not crossed with teraploid representatives of the *M. guttatus* and *M. luteus* complexes so the pairing behavior of the chromosomes of these second genomes was not observed.

The hexaploid level of the *M. glabratus* complex comprises *M. pilosiusculus* and *M. glabratus* var. *parviflorus*. In the fertile  $F_1$  hybrid, *M. glabratus* var. *parviflorus*  $\times$  *M. pilosiusculus* (6184  $\times$  5320), all the microsporocytes showed 14 to 16 pairs (table 2). Apparently these two species have only the basic genome in common. Neither the second nor third genomes display any significant amounts of homology. When the  $F_1$  hybrid, *M. pilosiusculus*  $\times$  *M. glabratus* var. *fremontii*, (5320  $\times$  5373) was studied pairing was not significantly better and the plants failed to set seed. The cross of *M. pilosiusculus* with the California culture of *M. glabratus* var. *fremontii*, 5320  $\times$  5063, failed to yield any hybrids which emphasizes anew the difference between the two forms of *M. glabratus* var. *fremontii*.

Chromosome pairing in the  $F_1$  hybrids of combinations of  $n = 46$  cultures of *M. glabratus* var. *parviflorus*, specifically, 6184  $\times$  6162 and 6184  $\times$  6163, ranged from 19 to 28 pairs. Apparently all three populations have two almost fully homologous genomes. The results for the  $F_1$  hybrid 6162  $\times$  6163 confirm this suggestion (table 2). All these  $F_1$  hybrids were fertile.

Chromosome pairing in the  $F_1$  hybrids of combinations of the  $n = 45$  culture, 5041, of *M. glabratus* var. *parviflorus* with  $n = 46$  cultures 6162 and 6163 yielded considerably less pairing than was observed in the intra  $n = 46$   $F_1$  hybrids (table 2). Essentially most cells showed pairing of one genome and only a small proportion showed additional pairs. Apparently there is a modest amount of homology between either the second or third genomes of culture 5041 and the corresponding chromosomes of the rest of *M. glabratus* var. *parviflorus*. These hybrids were sterile which underlines the difference between this  $n = 45$  culture and the rest of *M. glabratus* var. *parviflorus*.

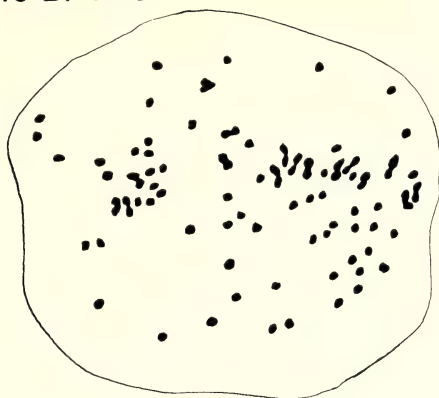
In summary, this investigation reveals that the common genome thought to be present throughout section *Simiolus* (Mukherjee and Vickery, 1962) has become significantly modified to a greater or lesser extent in each of the four species complexes. The results suggest the presence of at least five distinctly different second genomes, one in *M. luteus*, the second in tetraploid *M. guttatus*, the third in the Texas race of *M. glabratus* var. *fremontii*, the fourth in the California race of *M. glabratus* var. *fremontii*, and the fifth in the various South American populations of *M. pilosiusculus* and *M. glabratus* var. *parviflorus*. Occasionally a few of the chromosomes of the various *parviflorus* second genomes will synapse, but not consistently in any of the hybrids. The chromosomes of the second genomes of the hexaploids, *M. pilosiusculus*  $\times$  *M. glabratus* var.



0 5 10  
micra

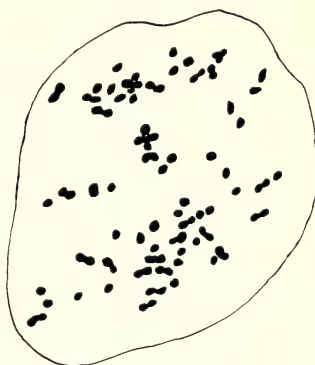


16 II. 60 I



6184 x 5320

27 II. 38 I



6184 x 6162

0 5 10  
micra

FIG. 2. The original camera lucida drawings were at a magnification of  $\times 2,400$ . They were reduced to approximately  $\times 1200$  in this figure. See Fig. 1 for explanation.

*fremontii* show the most pairing. Curiously, none of the five hexaploid populations showed any pairing of the chromosomes of the third genomes in their  $F_1$  hybrids (table 2) yet most of these hybrids were fertile. Possibly these genomes are homologous but the chromosomes separate precociously or, possibly, at this polyploid level the loss or gain of a few chromosomes is not critical to fertility. Apparently, the first genomes of members of section *Simiolus* are beginning to diverge significantly, the second genomes have often diverged almost completely, and the third genomes, at least of those tested, seem to have become ntirely distinct.

This investigation was supported by grant no. G 10603 from the National Science Foundation and by grants from the University of Utah Research Fund. Most of the results form a portion of the dissertation of the senior author submitted to the faculty of the University of Utah in partial fulfillment of the Ph. D. requirements.

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FIG. 1. Pairing behavior of the chromosomes in  $F_1$  hybrids of intra-*Mimulus glabratus* crosses and of combinations between *M. glabratus* and its related species. All figures are in or near first metaphase division. Camera lucida drawings were made at an original magnification of  $\times 2,850$  reduced to approximately  $\times 945$  in this figure.

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IDENTITY OF THE OAK TREE AT LIVE OAK TANKS,  
JOSHUA TREE NATIONAL MONUMENT, CALIFORNIA

JOHN M. TUCKER

Oaks are no rarity in Joshua Tree National Monument. The desert scrub oak, *Quercus turbinella* Greene ssp. *californica* Tucker, a shrub or small shrubby tree, is quite common and locally abundant. Two other species, *Q. dunni* Kell. (*Q. palmeri* Engelm.) and *Q. chrysolepis* Liebm., also are found in the Monument, although at only a few locations (Adams, 1957). The former is a shrub; the latter also may be a shrub, but more commonly is arborescent. In the entire Monument, however, there is only one oak tree of any size—a symmetrical 30-foot tree (fig. 1) at Live Oak Tank (fig. 2).

The identity of this tree has long been a matter of conjecture and disagreement among Californian botanists. It is a white oak (a member of the subgenus *Lepidobalanus*), but clearly is not referable to any species recorded for California. This, plus the fact that it is a single, isolated individual of its kind, raises the possibility of its being a hybrid of some sort. In size, degree of lobing, and dentation of lobes, the leaves are very similar to certain hybrids between species with small, spinose- or mucronate-dentate leaves (as one parent), and species with moderately large, deeply lobed leaves (as the other parent); *Q. turbinella*  $\times$  *Q. gambelii* (Tucker, 1961), and *Q. dumosa*  $\times$  *Q. garryana* (Tucker, 1953) come to mind. The leaves of the suspected hybrid have mucronate lobes and teeth. Logically, one parent could have smaller leaves with spinose-dentate margins. This suggests *Q. turbinella californica*, which occurs with the putative hybrid at Live Oak Tank. As for the other parent, it should logically be another white oak, for no authentic case is thus far known of natural hybridization between different subgenera. If we attempt to extrapolate the characters of the other parent in the manner of Anderson (1949), the detailed reasoning of such an analysis would be that presented in Table I.

TABLE I. EXTAPOLATION OF THE CHARACTERS OF THE SECOND PARENTAL SPECIES OF THE PUTATIVE HYBRID.

Since <i>Q. turbinella californica</i> has (is):	but the putative hybrid has (is):	the probable second parent has (is):
Characteristically a shrub	A fair-sized tree	A large, or moderately large tree
Small leaves (commonly 15- 35 mm long) with very short petioles	Larger leaves (40-60 mm long) with longer petioles	Even larger leaves (over 60 mm long) with longer petioles
Dentate margins with spinose teeth	Moderately lobed leaves, the lobes mucronate	Deeply lobed leaves with rounded or, at most, obtusely pointed lobes
Grayish-green upper leaf surfaces	Moderate green to yellow-green upper surfaces	Dark green upper surfaces
Thin acorn cups that are scarcely, or not at all, tuberculate, and are turbinate to sub-hemispheric in shape	Thicker cups that are moderately tuberculate, and are hemispheric in shape	Thick, strongly tuberculate cups, that are hemispheric to deeply bowl-shaped
Nuts that are commonly on the order of 20-25 mm in length	Nuts that are mostly 30-35 mm in length	Nuts 40 mm or more in length

In all the western states only one species fits such a description—*Quercus lobata*. The leaves, acorns, and cups of the hybrid are compared with those of the putative parents in Figs. 3, 4, and 5, respectively. The nearest trees of *Q. lobata*, however, are approximately 150 miles to the northwest, along the south side of Antelope Valley in northwestern Los Angeles Co. This poses an obvious problem, which will be discussed later.

In addition to the characters listed in Table I, other significant but less obvious features of the hybrid could be mentioned: 1, the canescence of the acorn cups is very similar to that in *Q. lobata*, and 2, the stellate hairs of the lower leaf surface are intermediate, most clearly in the size of the lumen of the individual rays (fig. 6).

Another character in which the putative parents differ is the degree of leaf persistence. In *Q. turbinella californica* the leaves ordinarily persist through the winter. In *Q. lobata* they are completely deciduous, dropping in the fall or early winter. The hybrid is clearly evergreen and is thus more similar to *Q. turbinella* in this respect. (James R. Youse and Alan D. Eliason of the Monument staff kindly made observations on this character for me.) Aside from this one conspicuous physiological trait, therefore, the oak at Live Oak Tank is essentially intermediate between the two postulated parental species.

I take pleasure in naming this distinctive hybrid for Philip A. Munz, who in years past has shown considerable interest in its identity.

*Quercus* × *munzii* Tucker, hybr. nov. *Q. lobata* Née × *Q. turbinella* ssp. *californica* Tucker. Arbor ca. 9 m alta; ramuli diametro 1.5-2.5 mm griseo- vel brunneo-bubalini, plus minusve tomentosi; gemmae ovoideae,



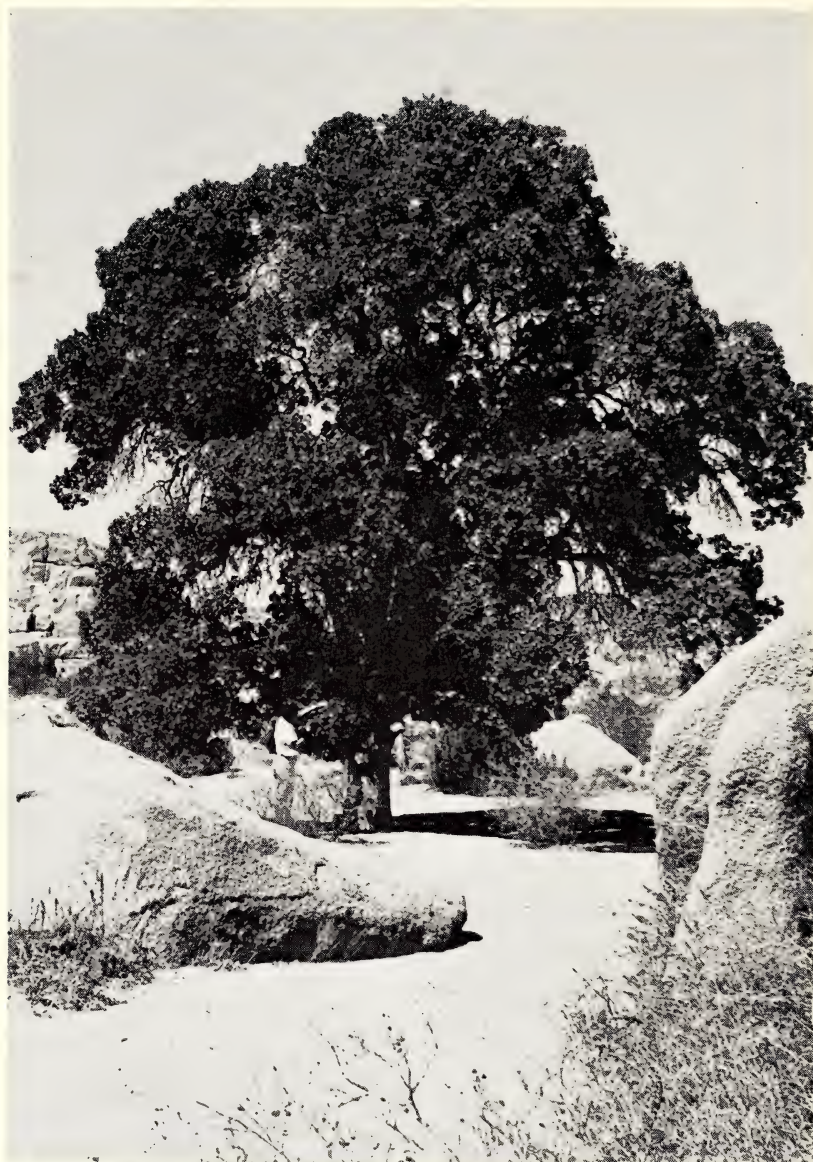


FIG. 1. The hybrid oak, *Quercus*  $\times$  *munzii* (*Q. lobata*  $\times$  *Q. turbinella* ssp. *californica*) at Live Oak Tank, Joshua Tree National Monument, Riverside Co., California.

sparse adpresso-pubescentes vere vel laeve brunneae, 2.5–4 mm longae; folia sempervirentia, 4–6 cm longa, 1.5–3.5 cm lata, ambitu obovata, basi late cuneata vel rotundata vel subtruncata, saepe inaequalia margine irrugariter leviterque lobata, supra vere vel luteovirdia, stellato-pu-



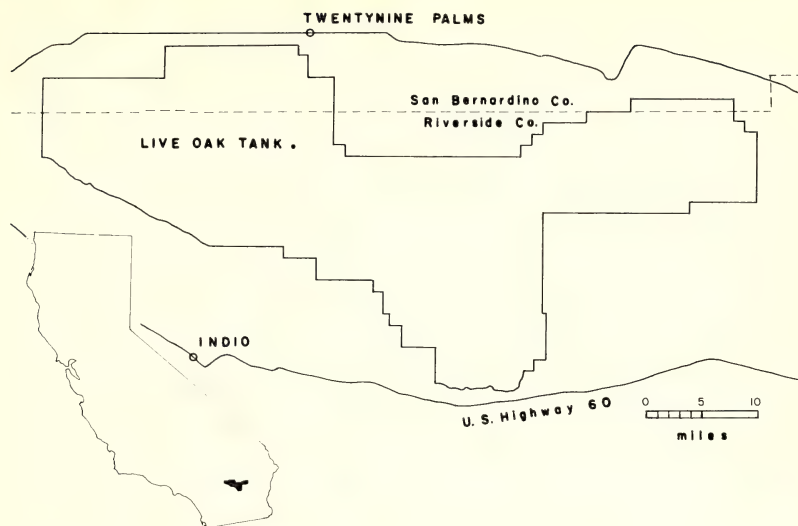


FIG 2.. Joshua Tree National Monument, showing Live Oak Tank, the location of the hybrid.

berulenta, subtus pallide viridia hebitiaque, dense sed minute adpresse stellato-puberulenta, lobis terminaliter 2-pluritaliter mucronate brevidentatis, venis utrinsecus 3-5; petioli puberulenti 5-8 mm longi; fructus annuus, cupula hemisphaerica, 13-19 mm lata, 6-9 mm alta, squamae plus minusve tuberculatae pallide brunneo-griseae, canescentes, apice sparsissime canescentes ac pallide brunneae; glans ovoidea demum atrobrunnea glabrataque, 30-35 mm longa, 12-17 mm lata.

Tree ca. 9 m tall with round, symmetrical crown; trunk ca. 7.5 dm in diameter at 6 dm above ground. Trunk bark light brownish-gray, flaky, rather soft and corky. Twigs of the current year's growth 1.5-2.5 mm in diameter, grayish- or brownish-buff, moderately tomentose, with small, inconspicuous, light-colored lenticels. Buds 2.5-4 mm long, ovoid, sparsely appressed-pubescent, medium to light brown in color. Stipules not seen. Leaves evergreen, obovate (sometimes narrowly so) in outline, 4-6 (or 8) cm long, 1.5-3.5 (4) cm broad, base broadly cuneate to rounded or sub-truncate, often unequal, margin irregularly and shallowly lobed, the lobes 2- several-toothed, the lobes or teeth mucronate; upper surface medium to yellow-green, stellate-puberulent, lower surface pale green and dull, densely but minutely appressed stellate-puberulent; principal secondary veins 3-5 on a side; petioles 5-8 mm long, puberulent. Staminate catkins 2 cm or more long, rachis tomentulose, perianth glabrate, the margins of the narrow lobes irregularly fimbriate, the small, glabrous, oval anthers slightly exserted. Fruit annual; acorn cups hemispheric to bowl-shaped, 13-19 mm broad, 6-9 mm high, scales deltoid, tips of the upper ones tending to be ligulate, bases of the scales moderately tuberculate, light brownish-gray, canescent, the tips sparsely so and



FIG. 3. Leaves of *Quercus*  $\times$  *munzii* (middle row: *Tucker* 3886 and *Cavagnaro*). *Q. lobata* (top row: *Tucker* 3905), and *Q. turbinella* ssp. *californica* (bottom row: *Tucker* 3895 and *Cavagnaro*). Scale is in cm.

medium brown in color; acorn ovoid, 30–35 mm long, and 12–17 mm broad, dark brown at maturity, glabrate except for the minutely canescent apex.

Specimens examined. Live Oak Tank, 4,000 feet, Joshua Tree National Monument, Riverside Co., California: *Tucker* 3886 and *Cavagnaro* (holotype-DAV), Oct. 2, 1965; *Bowerman* 4100; *Munz* 11590 (RSA);



FIG. 4. Acorns of *Quercus*  $\times$  *munzii* (middle row: Tucker 3886 and Cavagnaro), *Q. lobata* (top row: Tucker 3905), and *Q. turbinella* ssp. *californica* (bottom row: Tucker 3895 and Cavagnaro). Scale is in cm.

*Eliason* and *Youse s. n.* (DAV), Jan. 17, 1966; *Eliason s. n.* (DAV), June 12, 1966.

The parental species are, for the most part, well-separated ecologically. *Quercus turbinella californica* is the shrubby, gray-leaved oak of the pinyon-juniper association along the western edge of the Mojave Desert,





FIG. 5. Acorn cups of *Quercus*  $\times$  *munzii* (middle: Tucker 3886 and Cavagnaro), *Q. lobata* (left: Tucker 3905), and *Q. turbinella* ssp. *californica* (right: Tucker 3895 and Cavagnaro). Scale is in cm.

and of the xeric chaparral in the more arid parts of the inner South Coast Ranges. *Quercus lobata* is the most characteristic tree of interior valleys in California. Old trees with massive trunks and enormously broad, rounded crowns are a familiar sight in many interior parts of the state. In some areas, however, the two species may occur in close proximity to one another. For example, *Q. lobata* occurs along U. S. Highway 99 about 2 miles northwest of Lebec, Kern Co., and *Q. turbinella californica* is abundant on the adjacent hillsides. They also occur together along Oak Creek, 14 miles west of Mojave, Kern Co., on the desert slopes of the Tehachapi Mountains. The tree at Live Oak Tank, however, is the only hybrid between them known to me.

The botanist concerned with experimentally testing a hypothesis of hybridity, may either (1) attempt to synthesize the hybrid by crossing the putative parents, or (2) make a progeny test, if seeds are available from the putative hybrid. In the latter procedure, if the seedlings segregate morphologically such that some of them resemble one putative parent and some the other, the hypothesis is confirmed.

To the best of my knowledge, no attempt has yet been made to cross the putative parents of *Q. x munzii*. Progeny tests, however, have been attempted at least twice. In Oct., 1946, Munz collected acorns from this tree. From these, 105 seedlings were eventually planted at the Rancho Santa Ana Botanic Garden (Percy Everett, pers. commun.). Munz observed subsequently that the young oaks differed markedly from one another. "Some began to grow fast and upright like young trees, others branched at the base and were shorter and more bushy; some were more deciduous than others" (Vanderspek, pers. commun.). Everett stated, however, that only one small plant was still alive at the date of his writing in 1963. On Nov. 22, 1956, ten years after Munz's collection, acorns were collected from the hybrid by Ralph D. Cornell (Landscape Architect, Los Angeles), and seedlings from these were planted at the Garden Oct. 17, 1957, according to Everett. Specimens were collected for me from the 11 plants still surviving in 1963. These were all more *turbinella*-like than the parent tree, having generally smaller and more conspicuously spinose leaves than the latter. Thus, they probably represented backcrosses to *Q. turbinella californica* which, as stated previously,



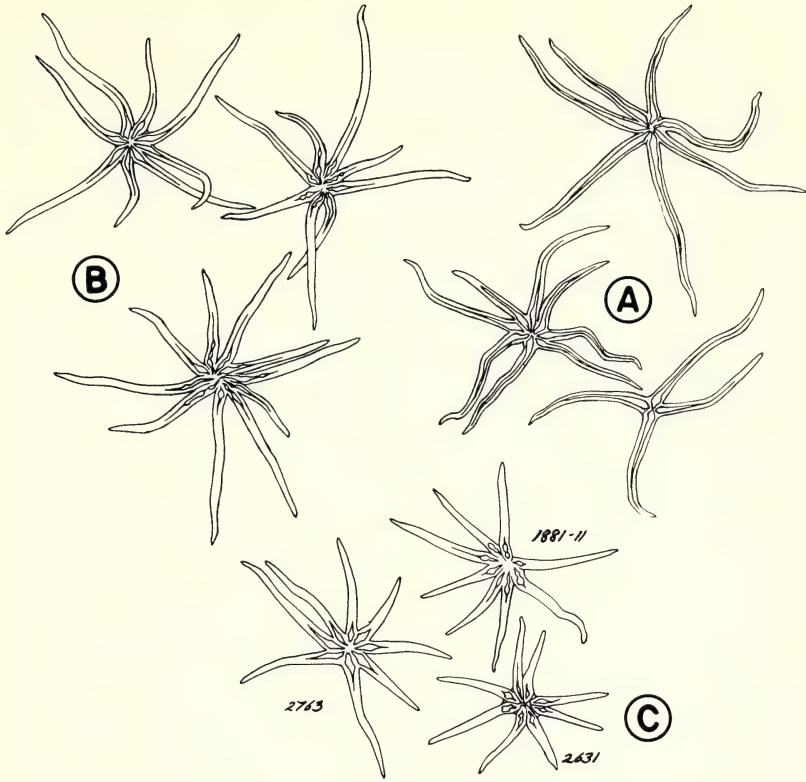


FIG. 6. Representative stellate hairs of the lower leaf surface of (B) *Quercus*  $\times$  *munzii* (Munz 11590), (A) *Q. lobata* (Tucker 3442), and (C) *Q. turbinella* ssp. *californica* (Tucker 1881-11, 2631, 2763). Drawings by Miss Jean Addicott; all  $\times$  ca. 50.

occurs in the immediate vicinity of the hybrid. Therefore, since none of them showed any more obvious evidence of *Q. lobata* ancestry than did the hybrid tree itself, the hypothesis that *Q. lobata* is one of the hybrid's parents was neither confirmed nor refuted by this progeny test.

In considering the origin of the hybrid, the most likely hypothesis, in my opinion, is that it was produced *in situ* from a direct cross between *Q. lobata*, probably as the pistillate parent, and *Q. turbinella californica*, as the pollen parent. This sympatric occurrence of the 2 at Live Oak Tank could have been as recent as 150 to 175 years ago, for the hybrid probably is best regarded as an  $F_1$ , and does not appear to be an exceptionally old tree.

Another possible, but much less probable, explanation is that the hybrid resulted from long-range pollination. Such an occurrence would have required a series of interrelated conditions including (Cottam, Tucker, and Drobnick, 1959; Tucker and Maze, 1966): 1, an overlap in the

flowering times of *Q. lobata* at its southeastern limits and *Q. turbinella californica* at Live Oak Tank; 2, the occurrence, during the flowering period, of wind from the northwest or west sufficiently sustained to carry pollen the 150 or more miles between the two areas; 3, pollen sufficiently resistant to solar radiation to be capable of germinating after a wind-borne journey of several hours (Jaeger, 1961); 4, atmospheric phenomena which would cause some of the pollen to drift down at Live Oak Tank and settle precisely upon the minute stigmas of the flowers of *Q. turbinella californica* at a time of receptiveness. The probability of all these requirements having been met appears very low indeed. But even granting the *possibility*, it seems that such long-range pollination would stand much less chance of *effecting fertilization* than the pollen of *Q. turbinella californica*, which also would have been present, and in far greater abundance. Apparently, fertilization of a pistillate flower is better effected by pollen of its own species than by that of a foreign species, in cases where pollen of both is present. Whatever the basic physiological reason, the validity of this assumption may be inferred from the fact that hybrids between distantly related species of *Quercus*, as in the present instance, are rarely found in areas where both species are abundant. On the contrary (Palmer, 1948), they usually are found in areas where one species is abundant but the other is scarce, occurring only as infrequent, isolated individuals. Under such circumstances, it can be assumed that the rare species most probably is the female parent. Its chances of being pollinated by pollen of its own species would be extremely low, except for the limited possibility of self-pollination, whereas its chances of being pollinated by the abundant species would be very great.

In seeking an explanation to account for the occurrence of *Q. lobata* so far south and east of its main, continuous distribution, one cannot ignore the possibility of long-range transport, and inadvertent "planting" of an acorn of *Q. lobata* by Indians. The possibility appears rather remote, however. There seems to be no evidence that acorns were an item of barter between tribes of the Great Valley, or adjacent areas where *Q. lobata* flourished, and those as far east as Joshua Tree Monument (Sample, 1950). The area with which we are concerned, at least the vicinity of Twenty-nine Palms, was evidently territory of the Serrano (Kroeber, 1908, p. 33), a Shoshonean group centered in the San Bernardino Mountains. Although the statement has been made that "acorns were fairly abundant in the western part of Serrano territory, but the eastern bands got their supply from the western ones, or substituted other foods" (Kroeber, 1925, p. 618), such acorns would hardly have been those of *Q. lobata*, for this species probably did not occur in Serrano territory.

Kroeber's statement that "*Quercus lobata* was the species that the Cahuilla [a tribe of San Gorgonio Pass and the Colorado Desert] had most frequently accessible to them" (1925, p. 695) is evidently erroneous. From Barrows' very detailed survey of the plants utilized by the

Cahuilla, it is evident that they relied on species indigenous to their area (Barrows, 1900).

The most plausible hypothesis, in my judgment, is that *Q. lobata* had migrated southeastward at some period in the past, when climatic conditions were moister than at present. Subsequently, with a shift to drier conditions, the species was reduced in numbers, and finally eliminated altogether. First, however, it hybridized with the abundant and more drought-adapted *Q. turbinella californica* to produce the hybrid tree at Live Oak Tank.

The pluvial periods of the Pleistocene could have provided the opportunity for such a southeastward migration. However, it should be kept in mind that the last such period, the Wisconsin, was followed by a period of several thousand years that was warmer, and possibly drier, than the present. It seems likely that during this Post-Wisconsin Altithermal (Antevs, 1955) or Hypsithermal Interval (Deevey and Flint, 1957), the range of *Q. lobata* would have extended no farther southeastward than it does today, and probably not so far. Thus, its southeastward migration to the area of Live Oak Tank probably occurred after the Hypsithermal, during a period when the climate of southern California was wetter than at present.

Evidence from tree-ring analyses leaves little doubt that there have been marked climatic fluctuations in the western United States within the last several millennia. Schulman (1956) has noted that long-term shifts to wetter or to drier conditions were typical in southern California for a number of centuries preceding the mid-1600's (although these gave way to swings of much shorter duration after that time). In our present phytogeographic problem, tree-ring evidence may well provide answers to some of the questions. Certainly, a tree-ring analysis of the hybrid would give the approximate date of the initial hybridization. Although a sizeable body of dendrochronological data is at hand for the Southwest, comparable information for southern California is, as yet, very scanty. In future years, however, when many more tree-ring chronologies have been worked out for southern California such as that by Schulman (1947) for big-cone spruce, we will be nearer a solution to what, for the present, remains an intriguing riddle.

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## NOTES AND NEWS

CONFUSION IN AUTHORSHIP OF *STEMODIA VERTICILLATA* HASSLER.—In 1964 I collected a small, weedy member of the Scrophulariaceae in a pasture at Horneman's Ranch ("Bella Vista") about 4 miles north of Bahia Academy, Isla Santa Cruz (Indifatigalbe I.), El Archipiélago de Colon (Galapagos I.), Ecuador.

While trying to identify this material, I found that it keyed to *Stemodia verticillata* (Mill.) Sprague, in Standley's *Flora of Costa Rica* (Fieldiana, Bot. 18:1111. 1938). A check of the Gray Herbarium Card Index revealed that this combination had been made twice prior to the publication of Sprague's paper (Bull. Misc. Inform. 1921:205-212. 1921). In each of the three cases, *Erinus verticillatus* Mill. (Gard. Dict. ed. 8, no. 5. 1768) was the basionym, so there is no doubt that each author was dealing with the same entity.

In 1909 Hassler (Trab. Mus. Farm. Fac. Ci. Med. Buenos Aires 21:110. 1909) published the transfer of *verticillatus* from *Erinus* to *Stemodia*, displacing the later *S. parviflora* Ait. Owing to the restricted circulation of this publication, Hassler's combination was overlooked and Boldring again made the transfer (Zakfl. Landbouwstr. Java 165. 1916). In 1921 Sprague, failing to find the earlier papers, published *Stemodia verticillata* as a new combination for the third time.

Therefore, this weedy herb, which is widely distributed in the American tropics and has been introduced elsewhere, together with its applicable synonymy, should be listed as follows:

*STEMODIA VERTICILLATA* (Mill.) Hassler, Trab. Mus. Farm. Fac. Ci. Med. Buenos Aires 21:110. 1909. *Erinus verticillatus* Mill., Gard. ed. 8, no. 5. 1768. *Capraria humilis* Ait., Hort. Kew. ed. 1. 2:354. 1789. *Stemodia parviflora* Ait., Hort. Kew. ed. 2. 4:52. 1812. *Stemodia arenaria* H. B. K., Nov. Gen. Spec. 2:357. t. 175. 1817. *Conobea pumila* Spreng. Nov. Prov. 13. 1819. *Stemodia verticillata* (Mill.) Boldr., Zakfl. Landbouwstr. Java 165. 1916. *Stemodia verticillata* (Mill.) Sprague, Bull. Misc. Inform. 1921:211. 1921.—IRA L. WIGGINS, Dudley Herbarium, Stanford University.



# SEED ECOLOGY OF SEQUOIADENDRON GIGANTEUM

N. STARK

Since the discovery of giant sequoia (*Sequoiadendron giganteum* (Lindl.) Buchh.) over 100 years ago, people have been concerned about "perserving these forest monarchs." Yet little is known about seed germination in nature. Many visitors to the California groves ask why there are so few young giant sequoias visible. The answers to this question are most important to the survival of the species. Since we cannot preserve indefinitely the mature trees, we must learn more about seed and seedling ecology to encourage reproduction of the species in nature. This study is one of three and is aimed at a better understanding of the reaction of seeds of the species to the environment both in nature and under laboratory conditions. The other two studies include a field inventory of the rate of reproduction, and the response of seedlings to environmental extremes.

The proper scientific name of the species and its generic designation are still controversial subjects (Buchholz, 1939; Doyle, 1945). The author prefers to use *Sequoiadendron giganteum*.

## DESCRIPTION OF THE HABITAT

Eighty or more groves of *S. giganteum* are located on the west slope of the central Sierra Nevada of California at elevations of 4,430–7,540 feet (Anon, 1952). A few trees grow naturally above these elevations.

The range of groves extends a distance of 250 miles from the middle fork of the American River in Placer Co. south to Deer Creek in Tulare Co. Although its natural distribution is limited, this species is planted successfully in at least 14 other countries (Stanford, 1958).

Summers in the natural range of the species are warm and dry with almost no precipitation except for occasional light thunderstorms. Most of the annual precipitation (ranging between 24.8 and 35.8 inches) falls as snow beginning in October or November and continuing through April or May. Annual snow accumulation varies from 45–185 inches.

The warmest month of the year is August when daily air temperatures may rise to 40°C, but often drop to 2°C at night. Intense summer solar radiation on exposed sites may heat the soil surface to 65°C while temperatures on shaded sites may be as much as 16°C lower.

The winters are cold; air temperatures seldom exceed 10°C during the day and sometimes drop to minus 23°C at night. The average annual frost free period is 124 days.

Mountainous terrain with deep valleys and grassy meadows characterize the range. The main rock formations are granite, schist, diorite, and andesite. Lava caps are common on the higher peaks.

Most of the groves are on unglaciated terrain but some can be found on glacial moraine. The soils are mainly shallow and rocky but include some deep sandy loams. They are weakly to moderately acid and are

generally well-drained (Zinke and Crocker, 1962).

The groves are not pure stands but contain these main tree species: *Abies concolor* (Gord. & Glend.) Lindl., *Libocedrus decurrens* Torr., *Pinus jeffreyi* Grev. & Balf., *P. lambertiana* Dougl., *P. murrayana* Grev. & Balf., *P. ponderosa* Laws., *Sequoiadendron giganteum* (Lindl.) Buchh., and *Taxus brevifolia* Nutt. A checklist of plants found in and around the groves provides a more complete picture of the flora (Stagner, 1951).

Ferns, mosses, herbs, grasses, and brush are common in some groves. Continuous mats of herbaceous and low shrubby vegetation once grew in most groves, but heavy recreational use of some areas has severely reduced the ground cover (Hartesveldt, 1962).

#### DESCRIPTION, RESULTS, AND DISCUSSION OF TESTS

Each germination experiment used 10 sets of 100 seeds each placed on moist filter paper in Petri dishes, unless otherwise noted. Seeds used in each of the tests came from five different areas, representing the natural range of the species. Since no significant differences occurred among sources by area, data represent averages of the five sources for each test. Light, moisture, and temperature were standardized with only one factor varying at a time as described below. The ability of the seeds to extend the radicle and free the cotyledons in 32 days served as a criterion of successful germination. In preliminary tests, the highest total germination occurred in reduced light (5,000 f.c.) at temperatures between 10° and 20°C. The tests and results are as follows:

1. Germination of Controls (20,000 seeds). Germination percent in reduced light (3,000 to 5,000 f.c. day, dark night) on moist filter paper at temperatures of 15°C  $\pm$  1°C) was used as a germination standard for all other tests. Control germination varied between 21.0 and 55.5%. Each test was compared to its companion control run of 10 sets of 100 seeds from the same seed source and year.

2. Germination and Temperatures (27,000 seeds).

- A. *Fixed Temperatures.* One thousand seeds were germinated in an incubator at each of these temperatures: 5°, 10°, 20°, 30°, and 40°C ( $\pm$  0.5°C) under 7,000 f.c. light day and night. At 10°C, 39.5% of the seeds germinated while at 20°C, 40.9% of the seeds germinated. All other temperatures produced germination below 39% (table 1).

- B. *Fluctuating Temperatures.* One thousand seeds were placed in Petri dishes in the weather station of the Experimental Plot (used for the seedling studies) every 32 days for 3 years to test germination under natural fluctuating temperatures. When the soil was not frozen, 100 seeds sewn in cheesecloth packets were planted in soil at 2 cm depth every 32 days to check germination in the soil environment. Moisture was added to half of the seeds daily except during the winter months when soil moisture was adequate for germination. Soil and air temperature records were checked against germination. Since fixed temperatures do not occur in nature for any appreciable length of time, germination

TABLE 1. GERMINATION PERCENT OF SEED AT FIXED TEMPERATURES—  
5,000 SEEDS TOTAL, 500 PER TEST

	5°C	10°C	20°C	30°C	40°C
Percent germination	4.1	39.5	40.9	5.6	0
Percent of control germination	7.4	91.6	94.9	12.9	0

under the influence of naturally fluctuating temperatures is the best indicator of the response of seeds to temperatures.

No one month is dependably better for germination since the climate varies slightly from year to year. In general, field moisture and temperature conditions favor germination in April and May, and sometimes in September in the central Sierra Nevada (table 2). October and November seeding usually gives good spring germination. Many seeds planted in the open in June, July, or August failed to germinate because of heat damage and rapid drying even when water was added daily. Lack of germination during the winter months is the result of low temperatures and frozen soil.

Absolute temperature limits on germination were not set, but seeds germinated poorly if air temperatures exceeded 33–34°C or fell below –2°C for any appreciable length of time (table 2).

3. Germination and Water (12,000 seeds). To test the influence of water depth and indirectly of oxygen deficiency on germination, one thousand seeds were germinated under each of the following depths of calm water: 0.5, 1.0, 2.0, 3.0, 4.0, 5.0, 10.0, 20.0 cm and under  $\pm 100$  cm of flowing water. Seeds were sewn into weighted cheesecloth packets. A similar test was run using one thousand seeds under 30 cm of water aerated by a pump. Water temperatures varied between 11° and 16°C.

The moisture tests were designed to indicate the ability of seeds to germinate under flooding conditions which often occur in the groves in the spring.

Seeds placed under different depths of water were swollen and few began to extend the radicle. None of the seeds under water for 32 or 64 days was able to completely extend the radicle or epicotyl. After 3 months under water, the seeds were covered by fungi and still showed no signs of germinating. Low oxygen tension in the water tests might explain germination failure. But it was not possible to measure directly oxygen availability to seeds under water. Seeds aerated in 30 cm water did not germinate either, although some were able to extend the radicle. No further germination occurred after 3 months of aeration. Eight percent of the seeds removed from aerated water after one month and placed on moist filter paper did germinate proving that these seeds were still alive. Comparable seeds from unaerated water tests were unable to germinate when placed on moist filter paper. Seeds in aerated water appeared to receive enough oxygen to maintain life for a month, but not enough to germinate.



TABLE 2. GERMINATION OF SEEDS UNDER NATURAL FLUCTUATING AIR TEMPERATURES (°C)—22,000 SEEDS.

	1959			1960			1961		
	% Germi- nation	Temp. Max.	°C Min.	% Germi- nation	Temp. Max.	°C Min.	% Germi- nation	Temp. Max.	°C Min.
January	—	—	—	0.0	13	—20	—	—	—
February	0.0	19	0	0.0	21	—18	—	—	—
March	9.8	24	—7.	6.7	21	—10	—	—	—
April	12.7	29	—7.	12.9	28	—10	—	—	—
May	48.5	34	—2.	25.2	34	—11	13.0	37	—1
June	0.0 <sup>1</sup>	37	+2.	19.3	37	— 2	10.0	37	+3
July	6.8	35	0	14.0	35	— 5	28.1	35	+2
August	15.4	31	—2.	14.3	34	— 3	—	—	—
September	38.2	31	—3.	36.7	26	— 6	—	—	—
October	—	—	—	—	—	—	—	—	—
November	20.0	25	—10.	0.0	27	— 3	—	—	—
December	0.0	18	—22.	0.0	19	— 3	—	—	—

<sup>1</sup> Failed because of drying. All other tests were kept moist.

There is little chance for *S. giganteum* to become established in areas inundated for more than a month. In the groves, widespread flooding rarely lasts more than a few days, but swamps, creek margins and depressions may remain under water for months.

4. Germination and Light (10,000 seeds). Germination tests used full light (7,000 f.c.), one-half full light (3,500 f.c.), and total darkness from the time of moistening. Light intensities were checked with a G.E. light meter. Temperatures ranged between 14°–16°C. Full light was created by placing the Petri dishes 1 m from a fluorescent light source. For half full light the same source was shaded to half intensity. For total darkness, the seeds were moistened after being placed in a black box in total darkness. Another test exposed the seed in covered dishes to full sunlight (10,000 f.c.) during the day.

Seeds showed 98 to 100% of control germination under half light (artificial) (table 3). When seeds were placed in full sunlight out-of-doors during the summer, the compound effects of heat to 60°C and rapid drying appeared to prevent germination. The influence of high light intensity in the absence of high heat was not studied. Seed germination is retarded and seedlings are etiolated in dark tests, but germination ranged between 64.6 and 75.7% of control germination.

In nature, *S. giganteum* seeds germinate on the litter surface or on mineral soil. Tests show that the litter surface resists wetting and dries quickly producing a poor seed bed. Rarely do the light seeds penetrate to the deeper, moist layers of the litter where germination can occur, but seedling emergence is unlikely because of limited reserve food. Mineral soil in full sunlight often dries too quickly for germination unless the seed is partly buried. Field tests and observations show that the best conditions for germination are disturbed mineral soil in moderate shade.



TABLE 3. PERCENT OF CONTROL GERMINATION UNDER VARIED LIGHT CONDITIONS—  
10,000 SEEDS

Test No.	Total Darkness	Half Full Light	Full Light
	0 f.c.	3,500 f.c.	7,000 f.c.
	Percent of Control		
1	75.7	100.0	0.0
2	64.6	100.0	0.0
3	73.1	98.0	0.0

Etiolation may enable seedlings arising deep in the soil or litter to reach the surface and begin photosynthesis, although etiolated seedlings 10 cm long often fail to recover in full sunlight. The precise location of seeds on the forest floor determines whether germination and growth can occur.

5. Germination and pH (16,000 seeds). Two thousand seeds were germinated in Petri dishes on filter paper moistened with  $H_2SO_4$  and NaOH solutions of the following pH levels: 2, 3, 4, 5, 6, 7, 8, and 9. The acidity of the solution was checked before moistening the filter paper and after 32 days using a Hellige pH kit. No measurable changes in pH occurred during the 32 days, but minor fluctuations probably did occur.

Soil acidity influences seedlings after germination more than seed germination itself. Acid solutions may be beneficial in scarifying the seeds, although scarification is not necessary to germination. At pH 6, germination was 82.6% of that of the controls while germination dropped to 63.3% of controls at pH 9, and 35.7% at pH 2 (table 4, 10°C). Germination was better at all pH levels at 20°C than at 10°C. Seedlings developed under pH 2, 3, and 4 were dwarfed with abnormal, stunted, reddened roots. Swelling developed in the root and root crown regions. Seedlings from seed germinated at pH 5 were slightly abnormal. All other treatments produced normal seedlings except for pH 9 where seedlings were dwarfed and intensely blue-green. Although pH 6 and 7 favor the best germination, soil pH should not limit germination in the groves which range from pH 5.6 to 7.9. The influence of sulfate ions in the solution cannot be overlooked in this test. It was not possible to separate the influence of the  $H^+$  ions from that of the sulfate ions.

Studies by Zinke and Crocker (1962) show that soil pH varies from acid at the base of a mature tree to progressively less acid away from the tree. The influence of pH on germination was tested in this study to determine whether variability in soil pH within the groves could limit germination.

6. Age of Seeds and Germination (4,100 seeds). The seeds tested had been stored for 1, 2, 3, 4, and 20 years, at  $-10^\circ$  to  $+10^\circ C$ . The 20-year-old seed was from a different source than the younger seeds, but its average germination at 1-year was almost identical with that of the 1-year-old seed used in this test. All seeds appeared to be sound, based on cutting a sample lot of seeds and examining the embryo. In these limited tests, seeds decreased in average viability by 32% in 20 years.

TABLE 4. PERCENT OF CONTROL GERMINATION OF SEEDS MOISTENED BY SOLUTIONS OF DIFFERENT pH VALUES—16,000 SEEDS

Temperature	Percent of Control pH							
	2	3	4	5	6	7	8	9
10°C	35.7	61.2	60.8	70.9	82.6	80.6	78.0	63.3
20°C	—	90.3	92.8	87.2	101.3	102.6	90.5	80.9

7. Depth of Planting and Germination (1,400 seeds). Seeds were planted from 0.2 to 6.2 cm deep at 0.2 cm intervals in mineral soil in a glassfaced frame, and the maximum seed depth allowing successful emergence over a 60-day period was determined.

In mineral soil, seeds can germinate at depths of 6 cm, but beyond about 2.4 to 3.6 cm, few seedlings can reach the surface.

In litter, seeds grow each day into a microenvironment with more light so that they can emerge from greater depths than in soil. Although seedlings endure etiolation to over 10 cm in total darkness, few of these severely etiolated seedlings survive in full light. At 10 cm depth, the litter is usually sufficiently moist for seeds to germinate, but few *S. giganteum* seeds can penetrate to this depth, and chances of seedling emergence are slim.

Tests with seeds of competing species show that larger seeds can penetrate the litter more effectively and produce seedlings which emerge from depths greater than 3.6 cm. *Sequoiadendron giganteum* seeds store a limited amount of food. The seeds of competing species store more reserve food than can *S. giganteum* seeds and can emerge from greater depths in the soil. This inability to germinate on dry surface litter, or to push through deep litter or soil is seriously hampering reproduction of the species which was formerly adapted to periodic fires that reduced litter depths. *Abies concolor* and *Libocedrus decurrens* which have less strict germination requirements are taking over gradually.

Many groves in undisturbed areas have local spots of good *S. giganteum* reproduction usually occurring in openings on slopes and often sites of old windthrows. Microerosion on these slopes tends to wash the seeds into the litter or soil. Many seedlings of all species grow here, but once established, *S. giganteum* can hold its own. Logged and burned groves normally have abundant reproduction (average of 7.3 young *S. giganteum* to each parent stump).

8. Chemical Inhibitors (6,000 seeds). The possible existence of chemical inhibitors in the litter of *S. giganteum* and mixed litter of *Pinus* spp. and *Abies concolor* was tested using water extracts (litter soaked for 24 or 48 hours) on seeds. No evidence of inhibition was found with the concentrations used.

9. Rodent Damage to Seeds and Food Preference. Six major food preference tests were set in the fall of 1960 and in the spring of 1961 in an area in the northern range of the species to determine whether repro-

duction failure is the result of seed-eaters destroying *S. giganteum* seeds. Twenty-four daily trials consisted of groups of 50 seeds, fruits, or cones of common trees. In the early trials, foods were placed in separate piles so that any disturbance was obvious. Later, the foods were mixed in piles so that seed-eaters had to sort through the seeds to locate those preferred. Isolated tests using only *S. giganteum* seeds were also made. The number of seeds removed were counted each day and the supply renewed.

These trials were not conducted in an area where seed-eaters commonly have access to *S. giganteum* seeds. Animals in the groves might react differently from those of adjacent areas. Seed-eaters were identified by periodic observation of feeding sites and trapping. The results were:

<i>Species</i>	<i>% of food parcels removed</i>
<i>Libocedrus decurrens</i>	0.1
<i>Abies magnifica</i>	0.3
<i>Juniperus occidentalis</i>	2.0
<i>Sequoiadendron giganteum</i>	3.0
<i>Abies concolor</i>	4.0
<i>Pinus sabiniana</i>	7.0
<i>Quercus kelloggii</i>	35.0
<i>Quercus chrysolepis</i>	36.0
<i>Quercus wislizenii</i>	40.0
<i>Quercus douglasii</i>	62.0
<i>Pinus ponderosa</i>	76.0
<i>Pinus jeffreyi</i>	82.0
<i>Quercus lobata</i>	84.0
<i>Pinus lambertiana</i>	86.0

Not all seeds, cones, and fruits were sound and their removal does not prove that they were eaten. The animals frequently left unsound food parcels of even the most sought-after species.

These results suggest that the small size and low food return of *S. giganteum* seeds or cones makes them undesirable to seed-eaters who prefer pine seed or acorns. In isolated tests using only sound *S. giganteum* seeds, *Peromyscus maniculatus* and *Eutamias speciosus* destroyed a few seeds. Preference for larger food parcels was noted during the fall in the caching period. *Cyanocitta stelleri* (Steller Jays) remove large quantities of acorns and pine seed, but whether these were eaten or not is unknown.

The most undesirable foods are the resinous seeds of *Libocedrus decurrens*, *Abies concolor*, *Abies magnifica*, and the cones of *Juniperus occidentalis*. The most desirable food was *Pinus lambertiana*.

The unattractive nature of *S. giganteum* seed argues in favor of a rapid spread of this adaptable species, but deep litter in the absence of fire is preventing its spread.

A. *Seed Size* (2,000 seeds). Exceptionally large sound seeds (8 mm



average length) germinated 153% better than sound seeds of mixed sizes. Soundness of seed was determined by cutting through a sample lot of seeds and determining if the seed appeared to be normal. Small apparently sound seeds (under 4 mm average length) germinated only 6.9% as well as the controls.

B. *Germination percent of seeds from 20-year-old trees* (194 seeds). None of the mature seeds collected from 20-year-old trees in a plantation near Pinecrest, California, germinated, even after stratification. Some of these seeds were not sound. It appears that the species does not produce viable seed at 20 years of age.

C. *Sequoiadendron giganteum* cone extract and seed germination (3,000 seeds). The red material containing gallic acid, pyrogallol, and sugars from the cones is credited with improving germination (Fry and White, 1938). Pigment solutions of 10, 25, 50, 75, and 85% by weight were used to moisten seeds in germination tests.

Cone extract in concentrated dosage (85%) retarded seed germination by one month. This concentration produced smaller seedlings than did the others. The slowing of germination and reduced seedling size may result from osmotic effects since the solution used was supersaturated. No concentration of the extract tested increased seedling size or vigor.

D. *The influence of fire on litter and germination* (6,000 seeds). In burned groves, young seedlings are often abundant. How does litter influence germination? Several hundred grams of litter from the McKinley grove were burned in an oven. Half of the litter was partly burned and the other half was reduced to a fine ash. Germination was tested using partly burned litter and ash dampened with water in Petri dishes. Half of the tests were covered to prevent drying and half were uncovered to the drying effect of air at 10°C. A related experiment using the gravimetric method determined the changes in dry weight and water holding capacity brought about by burning *S. giganteum* litter.

*Sequoiadendron giganteum* seeds placed on unburned litter exposed to the drying effect of the air did not germinate. The litter resists wetting and will float for some time on water, but the strong tendency for surface drying of the litter is unfavorable to germination. Litter floated on water but covered to reduce surface drying proved to be a good seedbed with 98.3% of control germination. Results on mineral soil indicate that germination parallels that of the filter paper controls as long as the surface is kept moist. Germination on ash was fair (51%) while germination on partially burned litter (covered) was good (98% of control).

Partially burned litter averaged 68% weight loss over unburned litter, but retained an average of 273% more moisture (by weight) than was retained by unburned litter. Burned litter is reduced in volume so that seeds do not have to penetrate deep layers of dry litter. Partly burned litter holds more moisture than unburned litter and seeds landing on the former have a good chance to germinate before it dries. Partial burning appears to increase the water holding capacity of litter by increasing the



number of spaces which can retain and give up water easily. Small hygroscopic cells which hold water tenaciously are broken into larger spaces which can take up and give up water more easily than can cellulose walls.

The black, heat absorbent, partly-burned litter should increase surface temperatures in the shaded, cool groves to levels well-suited to germination. Fire in the groves in years past appears to have aided natural reproduction in several ways (Biswell, 1961).

*E. Germination percent of the seeds from 42 groves* (12,000 seeds). Cones containing seeds on the ground were collected from 42 of the groves in 1959. One hundred seeds from each grove were tested for germination in Petri dishes, and another 200 from the same groves were planted in March at 1 cm depth in the soil and covered by litter.

The seeds from these 42 groves averaged 22.5% germination proving that the forest floor has the potential of producing many seedlings, but this potential is not being realized.

#### DISCUSSION

*Sequoiadendron giganteum* under natural conditions without fire protection is a long-cycle fire-climax species. Under protection from fire, it appears to be a subclimax species leading to a climax stand dominated by *Abies concolor*. The absence of natural wildfires is threatening the future of the giant sequoia.

The undisturbed *S. giganteum* groves before the advent of white man were adapted to periodic light fires and interims of 7–50 or more years for starting young growth. These light fires cleaned away dead or diseased trees and removed excess litter and debris so that reproduction was possible. Today there are an average of only 1.7 young trees (recent reproduction not yet producing cones) for each mature parent tree in the groves frequented by tourists. This scarcity of reproduction is traceable directly to the accumulation of litter on the forest floor. Where logging has disturbed the litter and exposed bare soil, there are 7.3 young trees to each old parent stump.

The reproductive potential for the species was based on an average of 2,000 cones per tree per year (figuring good and bad cone years) 210 seeds per cone, and an estimated average life span of 3,000 years.

The 1.2 billion seeds estimated per tree in a lifetime is corrected for 66% which are abnormal or are not released from the cones, 25% rodent damage, and 20% average germination. This leaves an estimated 60,000 potential offspring from one tree, more than enough to increase the natural range of the species. But the tree is not increasing its natural range in most places.

We cannot allow destructive wildfires in the Sierra Nevada today because of the threat to human life and property. We must find some means of producing the same conditions which fire used to create if *S. giganteum* is to flourish in nature. Perhaps gentle surface scarification of the forest floor will help to create new seedbeds. Where litter has

accumulated to depths of 0.5 to 0.7 m, the only hope appears to be mechanical removal. Any disturbance of the soil must take into account the shallow root system.

#### SUMMARY

Seed germination tests covered the influence of fluctuating and fixed temperatures, water, light, pH, age, planting depth, and seed-eaters on seed germination of *S. giganteum*. Studies aimed at understanding the failure of the species to reproduce abundantly in nature included the influence of seed size, cone extract, and seedbed conditions on the germination of *S. giganteum* seeds. Results show that:

1. Under fixed temperatures, *S. giganteum* seeds germinate well at 10° and 20°C (39.5 to 40.9%).
2. Germination under natural fluctuating air temperatures is best between -2° and +34°C, provided soil moisture is adequate.
3. Seeds will germinate on moist surfaces but not under water.
4. Seeds germinate best in reduced light (5,000 f.c.).
5. Germination is influenced slightly by pH, but seedling growth from seeds germinated below pH 5 is abnormal. Healthy seedlings and good growth resulted from seeds germinated at pH 6, 7, and 8.
6. *Sequoiadendron giganteum* seeds decreased in viability by 32% in 20 years (limited data).
7. Seedlings seldom reach the surface if seeds are germinated below 2.4 to 3.6 cm in the soil, depending on the degree of compaction.
8. No chemical inhibition of germination by litter extracts or cone extract was found.
9. Larger seeds germinate better than small seeds by as much as 146%.
10. Partially burned litter can hold up to 273% more available water by weight than unburned litter and forms a good seedbed.
11. Seed-eaters prefer the seeds of *Pinus lambertiana* (sugar pine) and the acorns of many oaks to *S. giganteum* seed.
12. The failure of the trees to spread and expand their present range is the result of deep layers of surface-dry litter which make germination and early survival difficult for trees with such small seeds.

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## A CYTOTAXONOMIC STUDY OF A NATURAL HYBRID BETWEEN AGROPYRON CRISTATUM AND *A. SUBSECUNDUM*

W. S. BOYLE and A. H. HOLMGREN

Reports of interspecific hybrids in the Tribe Triticeae of the Gramineae have become commonplace except for those involving diploid *A. cristatum* (L.). Gaertn. Grass hybrids involving New World and Old World *Agropyron* are few in number (Dewey, 1967; 1964a; 1964b; (1961). The present paper reports an *A. cristatum* hybrid found by the authors near the United States Forest Service boundary above Mendon, Utah in 1962. Two species of *Agropyron* were closely associated with the hybrid: *A. cristatum* and *A. subsecundum* (Link) Hitchc. Bowden (1965) and some other investigators have accepted the combination *A. trachycaulum* (Link) Malte for this entity and regard *A. subsecundum* as an awned variety of *A. trachycaulum*. No other species of *Agropyron* was found in the area after a careful search. *Elymus glaucus* Buckl. and *Hordeum jubatum* L. were present in the area but not in abundance and not near the hybrid. Specimens of the species and hybrid discussed in this paper are deposited at the Intermountain Herbarium at Utah State University.

**Comparative Morphology of Putative Parents and Hybrid.** The diploid *A. cristatum* growing within inches of the hybrid had glumes distorted near the base, curved awns, and blades strongly pilose on the ventral surface. These morphological characters will usually separate the diploid *A. cristatum* from the tetraploid, *A. desertorum*, where the glumes and awns are straight and the ventral surface of the blades glabrous or only slightly pilose. *Agropyron subsecundum* was typical of the plants found in northern Utah. The single bunch of the hybrid was conspicuous, as it appeared to be intermediate in most characters between the suspected parents.

The hybrid plant as it was found on the mountain produced spikes with solitary spikelets at each node of the rachis but clonal material grown in the field nursery had a tendency to produce two spikelets at a node on the lower part of the spike. *Agropyron subsecundum* and *A. trachycaulum* often do this when grown under optimal ecological conditions. *Agropyron cristatum* produces a single spikelet at each node under all conditions.



The spikelets of the sterile hybrid were not as crowded and strongly divergent as those of diploid *A. cristatum* but not as distant and appressed to the rachis as those of *A. subsecundum*. In these characters and the length of the spike the hybrid was intermediate between the putative parents (fig. 1). The glumes of the hybrid were only slightly distorted at the base and the awns were nearly straight, and the leaf blades were only slightly pilose on the ventral surface.

**Cytological Studies.** Both presumed parents had normal meiotic divisions. *Agropyron cristatum*,  $2n = 14$ , regularly formed  $7_{II}$  at metaphase I, in general confirming the observations of Dewey (1964a). *A. subsecundum*,  $2n = 28$ , is an allotetraploid regularly forming  $14_{II}$  at metaphase I and the meiotic behavior did not depart significantly from that described by Dewey (1966).

The sporophytic chromosome number of the hybrid is 21, as expected in view of the virtually certain progenitors described above.

It is questionable whether any gene exchange occurs between chromosomes in the hybrid. Of the 185 plates interpreted at diakinesis and metaphase I, 39 percent had 21 perfectly clear univalents (fig. 1). The remainder possessed a puzzling kind of chromosomal association involving one or two "pairs" of chromosomes. In 23 percent of the plates there were 19 univalents plus two chromosomes connected terminally by a slender matrix-like thread. In 14 percent there were 17 univalents and two "matrix pairs" present. In 11 percent there were one or two "pairs" of chromosomes associated simply end-to-end with no indication of an unterminalized region that is generally characteristic of rod bivalents in the Triticeae. The possibility of relatively rare formation of a chiasma in one arm cannot, however, be dismissed. The association observed may be of a homoeologous nature.

At telophase I, The univalents were distributed approximately equally to the poles. Frequently the chromatids were not well defined in contrast to normal telophase dyads. Equational division of univalents was rare. Lagging chromosomes were frequent but less numerous than in many hybrids in this tribe. Characteristically, telophase I chromosomes in the Triticeae do not return to the interphasic condition; only a partial relaxation of the coils occurs prior to re-orientation on the metaphase II plate. Telophase I chromosomes in the present hybrid were an exception to this. Increase in length and decrease in stainability was pronounced.

In most grass hybrids the lagging univalents that fail to become included within the nucleus at telophase I become spherical, very darkly staining micronuclei in the cytoplasm. This occurs to a limited extent in the present hybrid but in addition there exists another and more striking kind of micronuclei: one or many lagging chromosomes remain outside the nucleus, uncoil, and apparently become surrounded by a membrane. In addition, partially uncoiled chromosomes may be present outside the nucleus not surrounded by a membrane.



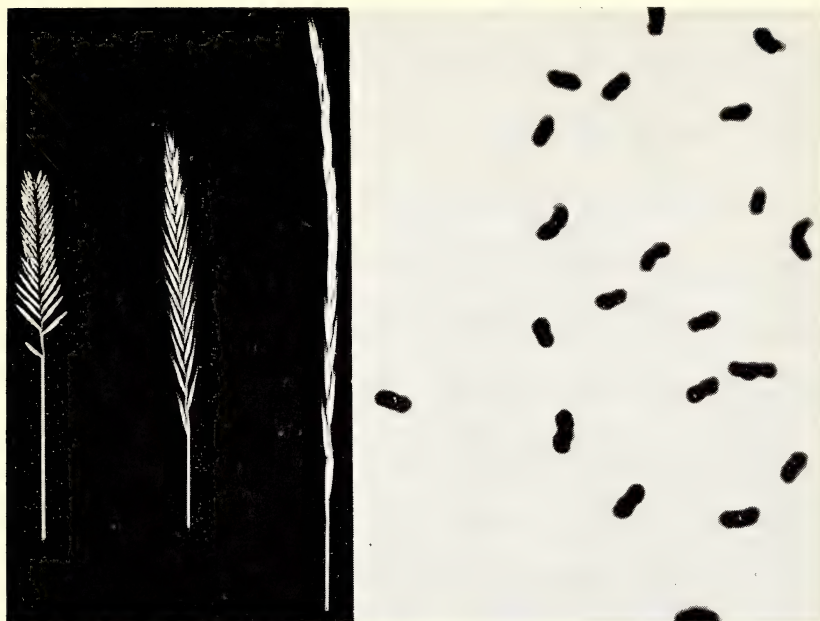


FIG. 1. Spikes of *Agropyron cristatum* (left), *A. subsecundum* (right), and the hybrid  $\times 2/3$ . Metaphase I in the hybrid, PMC. 21,  $\times 2400$ .

In the second division the chromosomes divided equationally in an essentially normal fashion and were distributed in approximately equal numbers to the poles. Laggards were often present and these formed typical micronuclei at the conclusion of the division. The unusual type of micronuclei described above for telophase I were not generally found at telophase II.

A substantial portion of the pollen mother cells never completed meiosis. Most mature anthers contained approximately half the normal number of pollen grains; some were virtually empty.

Many thousands of pollen grains have been observed in control plants during the course of radiobiological studies on this hybrid. All were judged to be sterile on the basis of staining reaction and abnormal, deformed structure. The hybrid is completely sterile.

Root tip squash preparations disclosed 21 chromosomes. The divisions were entirely normal and the plants of hybrid clones were unusually vigorous and hardy.

Braegger (1966), in a karyotype analysis of this hybrid, reported chromosome lengths ranging from 6.5–11.5  $\mu$  in a closely graduated series. All chromosomes possess median or sub-median centromeres. Bottino (1965) reported cyto-genetic effects of gamma irradiation on this hybrid.

**Hybridization Attempts.** Extensive attempts to produce a controlled *A. cristatum*—*A. subsecundum* hybrid were made in 1965 and 1966. Two special difficulties attend crossing these species: *A. subsecundum* flowers in early June and the florets open in the morning hours. *A. cristatum* flowers in late June and the florets open in the afternoon. The overlap time is short indeed.

In view of the reported self sterility of *A. cristatum* (Dewey, 1963) synthesis of the hybrid was attempted the first year without emasculation, with this species serving as the female parent. Both hand pollination, and pollinator culms of *A. subsecundum* sustained in bottles of water were utilized. The spikes were subsequently bagged. In all, 412 spikes of *A. cristatum* were used, and 212 seeds later obtained. Of these, 125 germinated and produced seedlings all of which proved to be selfed *A. cristatum*. Obviously, under the conditions of this experiment, some strains of *A. cristatum* are not self sterile.

In the second year approximately 20 florets in each of 95 spikes of *A. subsecundum* were emasculated and utilized as female parents. Thirty-three of the emasculated spikes were hand pollinated with pollen obtained from early maturing plants of *A. cristatum* grown in the greenhouse, and bagged. The remainder were bagged with pollinator culms of *A. cristatum* sustained in bottles of water in the conventional fashion. Ninety-five seeds were obtained, 51 of which germinated to produce vigorous seedlings. Root tip squash preparations disclosed that all 51 possessed 28 chromosomes and were not hybrids. It is difficult to see how such a high percentage of selfed *A. subsecundum* seeds could be obtained with the precautions taken. The possibility of apomictic development is therefore being investigated.

Diploid agropyrons in the Intermountain region are known only in the native *A. spicatum* and the introduced *A. cristatum*. This gives strong support that *A. cristatum* must be one of the parents of the triploid hybrid. Spike length, straight awns and proximity of the *A. subsecundum* to the hybrid suggests that this is in all probability the second parent.

We were unable to distinguish, with confidence, between chromosomes of *A. cristatum* and *A. subsecundum* in pollen mother cell divisions of the hybrid (fig. 1). Braegger (1967) was also unable to do this with mitotic chromosomes in root tip studies. However, he did find that the largest, satellited, and readily identifiable chromosome in the hybrid had a precise counterpart in *A. subsecundum*. In addition his total chromosome length studies in the hybrid and the presumed parents are closely consistent with the suggested origin of the hybrid.

The authors are pleased to acknowledge the many kindnesses of D. R. Dewey in allowing us to use the facilities of his field nursery, and to David Braegger and Keith Archibald for assistance in the field and laboratory.

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## THE WATER HYACINTH IN CALIFORNIA

JANE H. BOCK

*Eichhornia crassipes* (Mart.) Solms. (Pontederiaceae) commonly is called water hyacinth. The first record of *E. crassipes* in California was from a slough near Clarksburg, Yolo Co. (Smith, Sept. 30, 1904, UC). The first published account (Johnson, 1920) recorded it from the Centerville Bottoms, King River System, Fresno Co. I have found *E. crassipes* to be naturalized in California in the Kings, Tuolumne, San Joaquin, and Sacramento rivers systems (fig. 1). The northern limit of naturalization for this species in California was found in Babel Slough, about 10 miles northwest of Sacramento. This may be a world-wide northern limit for the weedy distribution of this species. The southern limit in California was in a pond draining from Lake Hodges, Clevenger Canyon, Ramona, San Diego Co. (Franklin & Buckner, Nov. 29, 1967, SD). The distribution of water hyacinths in California appears to be expanding since its early sightings in Yolo and Fresno counties. It still is found in these locations as well as in several new places (fig. 1). The distribution map is based upon personal observation and upon herbarium specimens (CAS, DAV, DS, Fresno State College, GH, LA, ND, NY, POM, RSA, SD, UC, UCR, UCSB, and US).

Unfortunately, no record exists of the progressive spread of *E. crassipes* in California, so that we must surmise how it occurred. Almost certainly, the species was introduced into the state by man as an ornamental. Subsequently, plants were put into California waterways. Plants from the Kings River system could have spread to the San Joaquin because of their proximity north of Fresno. And it is not difficult to imagine plants moving

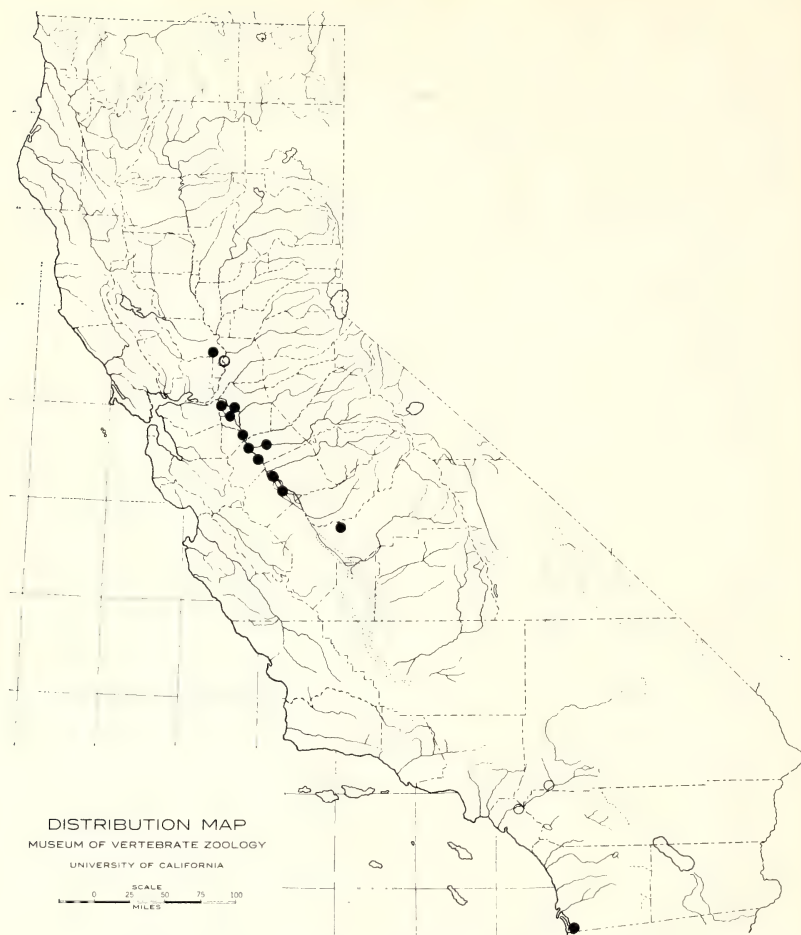


FIG. 1. Distribution of *Eichhornia crassipes* in California; present, solid circles; past, open circles.

between the San Joaquin and Tuolumne systems, since they meet nine miles west of Modesto. In addition, the Sacramento and San Joaquin systems meet north of Stockton. There is still more room for expansion available. For example, water hyacinths may move into the Stanislaus River and into new regions of the San Joaquin-Sacramento Delta in future years. In some areas, such as the Santa Ana River System, San Bernardino Co., water hyacinths are no longer found because of drought and drastic changes in the natural water supply which have accompanied the rapid increase in human population.

The water hyacinth, a native of the American tropics, owes its success in California to its extremely rapid rate of vegetative growth and reproduction and its wide range of environmental tolerances (Bock, 1966).



Each winter, thousands of plants are killed, especially in northern California, by the winter cold. However, enough survive through each winter to the following spring to serve as colonizers for the summer's growth, and to increase distribution. In spite of this natural seasonal control, water hyacinths should be watched carefully both by governmental water weed experts and by interested botanists.

This paper is a portion of a thesis for the Ph. D. degree at the University of California, Berkeley. The guidance of H. G. Baker and the assistance of my husband, Carl, are gratefully acknowledged.

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### NOTES ON ORYZOPSIS HENDERSONII (GRAMINEAE)

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Prior to 1966 the grass *Oryzopsis hendersonii* Vasey was known from only four collections. Three of these were from the vicinity of Mt. Clements in Yakima Co., Washington (Mt. Clements, *F. L. Henderson* 2249, 1892; Oak Ridge Rd., *D. B. Gray*, 1949; Oak Creek Game Range, *D. B. Gray & C. F. Martinsen*, 1950), the other from the Ochoco National Forest, Oregon (Trout Creek Basin, *D. C. Ingram*, 1916). In June, 1966, I discovered a large population north of Colockum Pass in NE Kittitas Co., Washington, extending the known range of the species northward 40 miles. Three more populations were found later, two in the early spring of 1967, along the north side of the Kittitas Valley in the vicinity of Ellensburg. These four new records, listed by my collection numbers, are as follows: 1450, on the Ellensburg—Wenatchee Rd. N of Clockum Pass, ca. 5 miles S of the Kittitas Co. line; 1465, 1466, 1467, stations one half mile apart along Trail Creek ca. 15 miles NE of Ellensburg; 1642, 1662, along Naneum Creek 9 miles N of Ellensburg; 1645, ridge top N of Hwy. 131, 3 miles E of Virden.

The first of these populations grew at 4,300 ft. elev., on a broad ridge top, in a nearly barren opening in mixed ponderosa pine—Douglas fir forest. The oryzopsis formed about 50% of the sparse vegetation in some portions of this area; the most common species with it was *Poa secunda* Presl. The other collections were made in similar habitats along the lower edge of the pine zone at about 3,000 ft. elev. Each population was found on rocky basaltic soil and occupied what appeared to be the driest site in the area.

The plants form low, dense, gray-green tufts up to 20 cm across and

are easily recognized in the field by this habit, even in the vegetative state. Previous descriptions indicate that the panicle branches are ascending or appressed. This is true of the upper ones, but as the culm continues to elongate during and after anthesis the lower branches may spread to an angle of ca.  $45-80^\circ$  to the main axis. This was observed in two populations in the field and in all plants that were taken from the field and grown at the University of Washington.

Cytological material was collected in the spring of 1967 from plants grown in Seattle. Root tips were treated and sectioned by the method Johnson (1945) used so that the karyotypes obtained would be comparable to those he studied in his cytotaxonomic treatment of the genus. Also, emerging panicles were fixed in Newcomer's fixative (Newcomer, 1953), rinsed in 70% alcohol, and stained with Snow's carmine (Snow, 1963). Permanent slides are filed with the voucher specimens at the University of Washington. From the root tips of plants from collections 1450 and 1465 I obtained counts of  $2n = 34$ , a number previously unreported for the genus; two of the chromosomes bear satellites (fig. 1). Counts of  $n = 17$ , made at various stages of meiosis in developing anthers, were determined in plants from each of the populations I found. No meiotic irregularities were observed and pollen from plants grown in Seattle was about 95% stainable with cotton blue in lactophenol.

It is generally recognized that *Oryzopsis* and *Stipa* are closely related, for each genus has some species with features that are used by taxonomists to characterize the other. In *O. hendersonii*, the presence of three, rather than two, lodicules, and the moderately differentiated callus may be considered stipoid features, as might also the convolute lemma, common in *Stipa*, but known elsewhere in *Oryzopsis* only in *O. asperifolia* Michx. Because of these morphological similarities to *Stipa*, and the chromosome number which is found in several species of that genus, the embryo was examined to see with which genus it correlated. Reeder (1957) pointed out that the embryo of *Oryzopsis* has a small epiblast, that of *Stipa* a large one that usually reaches the tip of the coleoptile, and that "the primary root is often bent at a rather sharp angle to the main axis of the embryo," a feature especially conspicuous in *Stipa*. I was able to confirm these conditions for *S. lemmonii* (Vasey) Scribn. and *O. exigua* Thurb. following the methods Reeder described. The embryo of *O. hendersonii* (fig. 1) compares well with that of the former species but not that of the latter, appearing distinctly stipoid. This might be considered as an indication of affinity to *Stipa*, but it should be noted that these alleged generic differences in embryology also break down in other species of *Oryzopsis*. For example, I observed the primary root of *O. miliacea* (L.) Benth. & Hook. to arise at nearly  $90^\circ$  to the axis; Bruns (1892) illustrated a large epiblast on *Piptatherum* (= *Oryzopsis*) *paradoxum* L.; and Kennedy (1899) illustrated the embryo of *Eriocoma cuspidata* Nutt. (*O. hymenoides* (Roem. & Schult.) Ricker) as having an epiblast extending nearly to the tip of the coleoptile, the

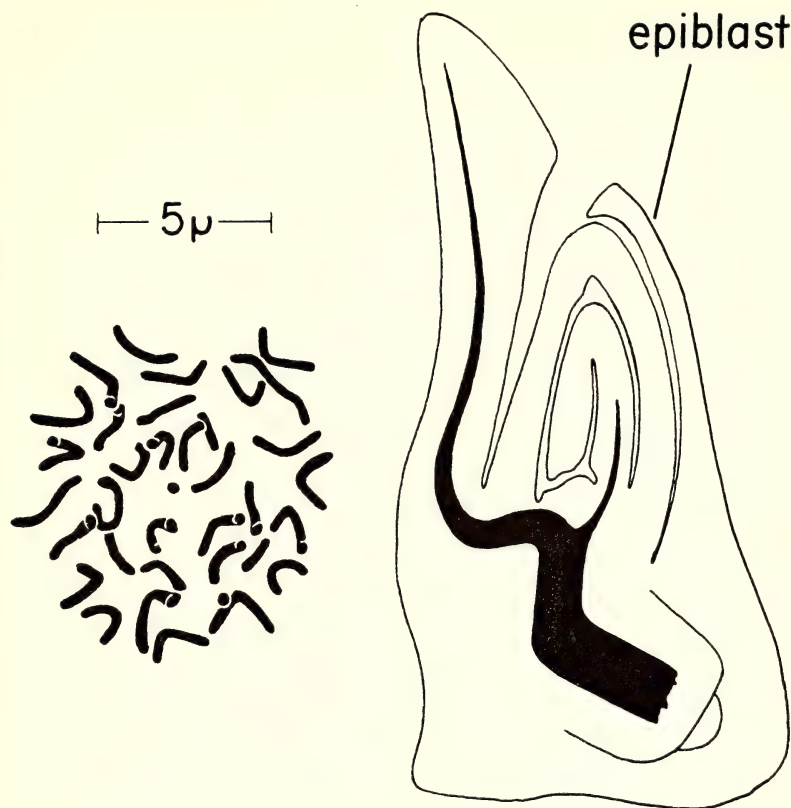


FIG. 1. Metaphase chromosomes from a root tip cell drawn with the aid of a camera lucida (left). Median longitudinal, section of embryo (right).

primary root arising at a sharp angle to the axis.

In his cytotaxonomic study of *Oryzopsis*, Johnson (1945) followed the conventional treatment in recognizing three sections, *Euoryzopsis*, *Piptatherum*, and *Eriocoma*. He found *Euoryzopsis* and *Piptatherum* to consist mostly of diploid species, those of the first section having  $2n = 22$  chromosomes, those of the second,  $2n = 24$ . Two species, *O. asperifolia* and *O. racemosa* (J. E. Smith) Ricker, were found to have a somatic complement of 46 chromosomes, and since they combine morphological features of both sections, he suggested that they were intersectional allopolyploids. In absence of cytological data, he discussed *O. hendersonii* with these two species because it has a similar combination of characteristics, indicating possible intermediacy between the two sections. Although I have found that its chromosomes are similar in length to those of the other two species and to the stipoid species in *Euoryzopsis*, it is unlikely that its complement (34) originated in the same way, followed necessarily by a loss of 12 chromosomes. However, if a basic number of 6 chromosomes, along with 11 and 12, is assumed in the early history of

*Stipa* and *Oryzopsis*, as has been suggested by Stebbins and Love (1941) and by Johnson, this complement may have arisen by allopolyploidy in one of the several ways they proposed for other members of these genera.

While having some features found in *Stipa*, *O. hendersonii* (sect. *Euoryzopsis*) shows possible affinities to section *Piptatherum* by the partly spreading panicle branches with distally placed spikelets, the wide, several-nerved glumes, and the dark, glabrous, dorsiventrally compressed, indurate lemma. Furthermore, the style branches, which are reflexed out of the side of the open floret at anthesis, resemble those of species in *Piptatherum* and also those of some species of *Stipa*, e.g., *S. lemmonii*. Johnson said that the form of the style branches (reflexed in *Piptatherum* but exerted from the tip of the lemma in *Euoryzopsis*) separates the two sections. Lacking critical material of *O. hendersonii*, he placed it in *Euoryzopsis*. Such disposition now appears to make that section somewhat unnatural, but the species does not fit well in any other subdivision of the genus either. Although it seems to occupy a fairly isolated position, I believe that removing it from *Euoryzopsis* would necessitate other sub-generic rearrangements. However, before such changes are made, further study of relationships within *Oryzopsis* is needed.

In summary, the information presented allows some speculation on the ancestry of *O. hendersonii*. Several morphological features indicate affinities to *Stipa*, but others reflect a relationship to *Oryzopsis* (sect. *Piptatherum*). Although native species in that section are not presently found in western U. S., Elias (1942) reported a fossil species of *Paleoeriacoma* from the Tertiary flora of Colorado which bears some resemblance to species in *Piptatherum*. The possibility that *O. hendersonii* is an allploid that originated from an ancient hybridization between *Stipa*-like and *Piptatherum*-like grasses is plausible if a basic number of 6, in addition to 11 and 12, is assumed for one or the other of these genera.

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## REVIEWS

*Flora of Turkey and the East Aegean Islands*, Vol. II. By P. H. DAVIS. xii + 581 pp. Edinburgh University Press; Aldine Publishing Co., Chicago. 1967. \$33.50.

Turkey, a vast country of some 300,000 square miles, has an exceptionally rich flora of vascular plants amounting to perhaps 8,000 species. This figure is consistent with the physiographic diversity of the area and with its crucial position at the meeting place of three vast phytogeographical regions, the Euro-Siberian, Mediterranean, and Irano-Turanian. About a fifth of the species of vascular plants found in Turkey appear to be endemic, with exceptionally rich concentrations in southern and eastern Anatolia. The only earlier comprehensive flora which includes the plants of Turkey is Boissier's six-volume *Flora Orientalis* (1867-1888). Vastly more information is of course available about the plants of Turkey at present, with the extensive collections of Peter Davis and his collaborators being of special importance.

The first volume of the present flora appeared in 1965, and thus the second conforms to the biennial schedule that is contemplated for the eight volumes that will be necessary to complete the flora. The flora includes keys and descriptions, essential synonymy and references, critical taxonomic notes and illustrations, selected distribution maps, citation of types, ecological and phenological information, and general distribution in Turkey.

Volume II includes a list of the major Turkish collections since the completion of the *Flora Orientalis* (i.e., 1888). In this volume are treated such familiar groups as Centrospermae (Caryophyllales, Chenopodiales), Malvaceae, Linaceae, Geraniaceae, Rhamnaceae, and Anacardiaceae. This volume includes families 12-44 of the overall work, and includes such large genera as *Silene* (119 spp.), *Hypericum* (69 spp.), and *Dianthus* (67 spp.). The Caryophyllaceae are the largest family treated, occupying 230 pages—well over a third of the volume. The treatment of genera in this family is of particular interest, since what has traditionally been regarded as *Arenaria* by North American botanists is broken up on persuasive grounds into *Arenaria* s. str., *Minuartia*, *Lepyrodiclis*, and *Moehringia*. *Melandrium* is regarded as a synonym of *Silene* but *Lychnis* is recognized as a distinct genus.

California botanists also will be interested in the division of the *Salsola kali* L. complex by Paul Aellen into *S. kali* and *S. ruthenica* Iljin (including var. *tenuifolia* Tausch.), but applicability of this taxonomic treatment to introduced populations in North America remains to be seen. *Arthrocnemum* is regarded as a genus of perennial plants distinct from the wholly annual *Salicornia*. *Frangula* is recognized as distinct from *Rhamnus*, and the relatively narrow generic standards thus conform closely to those of *Flora Europaea*. Perhaps it is now possible to achieve some measure of uniformity on the often arbitrary problems of the subdivision of genera, and it is to be hoped that the authors of subsequent floras will depart from the reasonable standards of *Flora Europaea* only when the preponderance of evidence is overwhelming.—PETER H. RAVEN, Department of Biological Sciences, Stanford University.

*A Handbook of Coniferae and Ginkgoaceae*. By W. DALLIMORE and A. B. JACKSON. Revised by S. G. HARRISON. Fourth Edition. xix + 729 pp. William Clowes and Sons Ltd., London and Beccles; and St. Martin's Press, New York, 1967. \$35.00.

The fourth edition of this book, which has been a standard reference work since 1923, exhibits a number of departures from the arrangement and treatment in the previous editions. Some parts are the same as those in the 1954 third edition; for example, the key to the sections is essentially the same, the only difference being the use of the term "male strobili" instead of "staminate flowers"; the keys to the genera are virtually the same and are trichotomous in several places; most of the figures are the same as those used in earlier editions.

In contrast, improvements have been made which clearly show the influence of Dr. Harrison. The order of the listing of taxonomic entities is strictly alphabetical

by genera, regardless of the family affiliation. This makes it easier to find an account covering a particular genus without referring to the index, and since the species recognized within genera are also listed alphabetically, it is now quite easy to find the textual coverage of any species. A possible fault in such an order may be that it precludes grouping closely related species or genera together, and one must skip around through many pages to consult the full description of the members of any of the larger families.

Another innovation is apparent in the location of the date of publication applicable to the references in the section on "Principal Works Consulted" immediately following the name of the author(s) instead of at the end of the citation.

In several cases the arrangement of back-to-back plates now brings related photographs together instead of having them widely separated as was the case in earlier editions. Thus, plates 37 and 38, following p. 524, bear two photographs of *Pseudotsuga menziesii* on opposite faces of the inserted plate, and the plates between 556 and 557 (plates 39 and 40) represent *Sequoia sempervirens* and *Sequoiadendron gigantea* respectively.

The number of named cultivars recognized and included in the text is increased over that of earlier editions, although doubt is sometimes expressed as to the correct systematic alignment of some of them.

The descriptions, as in earlier issues, is reasonably full, and largely non-technical. Economic importance of various species is well covered. Notes about climatic requirements, methods of propagation, characteristics of the wood, soil preferences, susceptibility to attacks by insect and fungous pests, and general suitability for garden or park plantings will be helpful to gardeners, whether they be professionals or amateurs. Added notes on age at which various species normally begin to produce seed, approximate number of seeds required to weigh one pound, reactions of the young and mature plants to smog and other industrial wastes often contain information found in few other places or only in scattered reports and papers.

The 4th edition contains 46 plates, 131 line drawings, and 118 references in the "Principal Works Consulted" as compared with 39 plates, 120 figures, and 83 references in the 3rd edition. The new line drawings are credited to Mr. H. R. W. Herbert, but there is no identifying mark or initials to indicate his work.

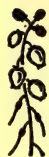
Typographical errors seem to be very few. Probably the most noticeable one occurs on page 15 where both the ordinal and family names are correctly spelled, but the genus *Ginkgo* in the generic heading is spelled "*Gingko*."

The index is a model of completeness and very careful work. Generic, specific, varietal, and common names are listed, as well as a huge number of cultivars.

The quality of the paper used in good, the printing excellent and clean-cut. The green buckram binding appears to be a bit light weight for a book of its size and may fail to hold up if the book is handled extensively—as many copies most surely will be. The authors' names, the title, and the American publisher's name appear on the spine in silver letters and give an attractive appearance to a shelved volume. This edition beyond doubt will be a standard reference work for years to come and should be received with enthusiasm and praise.—IRA L. WIGGINS, Dudley Herbarium, Stanford University.

## NOTES AND NEWS

JEPSON'S FLORA OF CALIFORNIA.—All published numbers of W. L. Jepson's "Flora of California" are still available at the original prices from the ASUC Store, University of California, Berkeley, California 94720. Such volumes rarely are listed in booksellers' catalogues, suggesting that it is not generally known that they are still available new. Although the Flora is incomplete, the parts published are very useful for amateur or professional botanists working in the western United States.—ROBERT ORNDUFF, Director, Jepson Herbarium and Library.



# MADROÑO

A WEST AMERICAN JOURNAL OF BOTANY

VOLUME 19, NUMBER 8

OCTOBER, 1968

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# MADROÑO

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## NEW SPECIES OF ERIOGONUM FROM UTAH

JAMES L. REVEAL

During the summer months since 1959 extensive field trips have been taken into the Intermountain Region in connection with the Intermountain Flora Project under the direction of Arthur Cronquist of the New York Botanical Garden. Several new and interesting plants have been found (Cronquist 1963a; b; 1964; Holmgren, 1967; Reveal, 1965; 1966a; b; c; 1967; 1968; a; b). This report is another in the series of contributions in which the various undescribed species are proposed.

The author is grateful to Arthur Cronquist for the opportunity to carry out field and herbarium studies on the Intermountain Region and adjacent areas. This work was largely supported by his National Science Foundation grants from 1964 to 1967, and lead to the discovery of the following new species. The assistance of Noel H. Holmgren of the New York Botanical Garden in the field during those years is appreciated. C. V. Morton assisted the author with the preparation of the Latin descriptions. The United States National Herbarium and the Smithsonian Institution sponsored the author's Predoctoral Internship program in Washington, D.C., from September 1966 to February 1967 where this paper was initially prepared. The illustrations were prepared by Mrs. Twila Davis Bird, formerly a student at Utah State University, under the direction of Arthur H. Holmgren, Curator of the Intermountain Herbarium. Up to thirty-five isotypes of the proposed taxa have been distributed from Utah State University.

**Eriogonum cronquistii** Reveal, sp. nov. Planta perennis herbacea implexa, 1–3 dm diam.; caules (0.7)1–1.5(2) dm alti, basi per 1–4 cm foliosi; laminae foliorum ellipticae, 0.5–2 cm longae, 4–10 mm latae, margine crenulatae et crispatae, subtus albo-tomentosae, supra subglabrae et virides, petiolis 3–8 mm longis, tomentosis, basi expansa petioli 1–1.5 mm lati; caules glabri, basi excepta, ca. 1 dm longi, bracteis 1 mm longis, extra glabris, intus tomentosis; inflorescentiae subcapitata vel cymosa, 1–7 cm longae, glabrae; involucria turbinata, 3 mm longa, sessilia, extra et intus glabra, 5-lobata, bracteolis filiformibus, 2 mm longis, pedicellis 2.5–3 mm longis, glabris; perianthia alba, (1.5)2–3 mm longa, extra glabra, intus minute glandulosa, segmentis similibus, oblanceolatis; stamina 2.5–4 mm longa, filamentis basi pilosis, antheris 0.3 mm longis; achaenia brunnea, 2–2.5 mm longa.

Herbaceous perennials from matted, highly branched and spreading, woody caudices, plants (0.7)1–1.5(2) dm high; leaves basal and sheathing up the stems 1–4 cm, leaf-blades elliptical with crenulate margins, 0.5–2 cm long, 4–10 mm wide, densely white-tomentose below, subglabrate and green above, the petioles 3–8 mm long, tomentose, the ex-



FIG. 1. *Eriogonum cronquistii*. Habit sketch showing the erect stems and leafy bases with an enlargement of the inflorescence showing the clustered involucres on short branches and the arrangement of the leaves on the base of the stem.

panded petiole bases 1–1.5 mm wide; stems glabrous and glaucous except for the tomentose bases among the leaves, up to 1 dm long; bracts scale-like, ternate, 1 mm long, glabrous without, tomentose within, the acute apices widening to connate bases; inflorescences open cymes up to 7 cm long, glabrous, dichotomously or trichotomously branched, subcapitate when immature; involucres sessile, 3 mm long, turbinate, glabrous within and without, angled with 5 ridges running down from the 5 acute teeth which form lobes  $\frac{1}{3}$  the length of the tubes, the teeth with membranaceous margins, the bractlets linear and thread-like, 2 mm long, the pedicels

2.5–3 mm long, glabrous; perianth white, (1.5)2–3 mm long, glabrous except for minute glands within along the midribs, calyx-segments  $\pm$  equal, the outer segments oblanceolate with rounded apices, the inner segments slightly narrower and shorter; stamens 2.5–4 mm long, the filaments pilose at the base, the anthers 0.3 mm long, reddish; achenes brown, 2–2.5 mm long, the subglobose bases tapering to smooth 3-angled beaks.  $n = 20$ .

Specimens examined. Utah, Garfield Co.: Loose decomposed granite talus slopes on the west side of Bull Mt., Henry Mts., Sec 6, T31S, R11E, 8,300 ft., *Holmgren & Reveal 3010* (holotype-UTC), Aug. 14, 1967; Bull Mt., *Cronquist & Holmgren 9442* (NY). Fig. 1.

This new species resembles *E. batemanii* M. E. Jones in several of its features and especially so in its glabrous cymose inflorescences, elliptic basal leaves and in flower and involucre size. Yet the two species may be distinguished by the crenulate leaf-margins of *E. cronquistii* and the shorter leaves than those of *E. batemanii* which tend to be 2–3 cm long. Also *E. cronquistii* differs in its loosely matted and spreading habitat which is unlike the more compact and not at all spreading habit of *E. batemanii*. In addition, *E. batemanii* is 2–4 dm high while the new species is rarely 2 dm high. In their ecology, the two species differ greatly. *E. cronquistii* is the only species in the subgenus *Eucycla* (Nutt.) Kuntze that grows strictly on talus slopes. The type area is a rock slide where the angle of repose is so great that the slightest disturbance can cause the talus to slide. In collecting specimens, the plants were found to have long creeping caudices—apparently a result of the habitat—and an entire plant is often up to two feet down slope from the point of primary root contact with the soil. On the other hand, *E. batemanii* is restricted to the heavy gumbo clay hills throughout much of the Uinta Basin and Grand Valley south onto the San Rafael Swells and the lower slopes of the Henry Mountains. *Eriogonum batemanii* never attains the elevations of *E. cronquistii* which grows in the rock slide from about 8100 feet to about 9250 feet.

It is a pleasure to name this new species in honor of Arthur Cronquist, Senior Curator of the New York Botanical Garden, who brought this plant to my attention.

***Eriogonum humivagans*** Reveal, sp. nov. Herba perennis, 2–3 dm alta; laminae foliorum oblanceolatae, 1.5–3 cm longae, 2–5(7) mm latae, basiles, subtus albo-tomentosae, supra subglabrae et virides, petiolis 5–10 (12) mm longis, tomentosus, basi expansa petioli, 1.5–2 mm lati; caules glabri, ca. 1 dm longi, bracteis 2–3 mm longis, extra glabris, intus tomentosus; inflorescentiae cymosa, stricta; involucria turbinata, 3–4 mm longae, 2–2.5 mm latae, sessilia, extra glabri, intus sparsi tomentosa, 5-lobata, bracteolis linearis, 3 mm longis, pedicellis 3.5–5 mm longis, glabris; periantha alba, costa brunnea, 3–3.5 mm longa, extra glabra, intus minute glandulosa, segmentis similibus, obovatis; stamina 3–5 mm

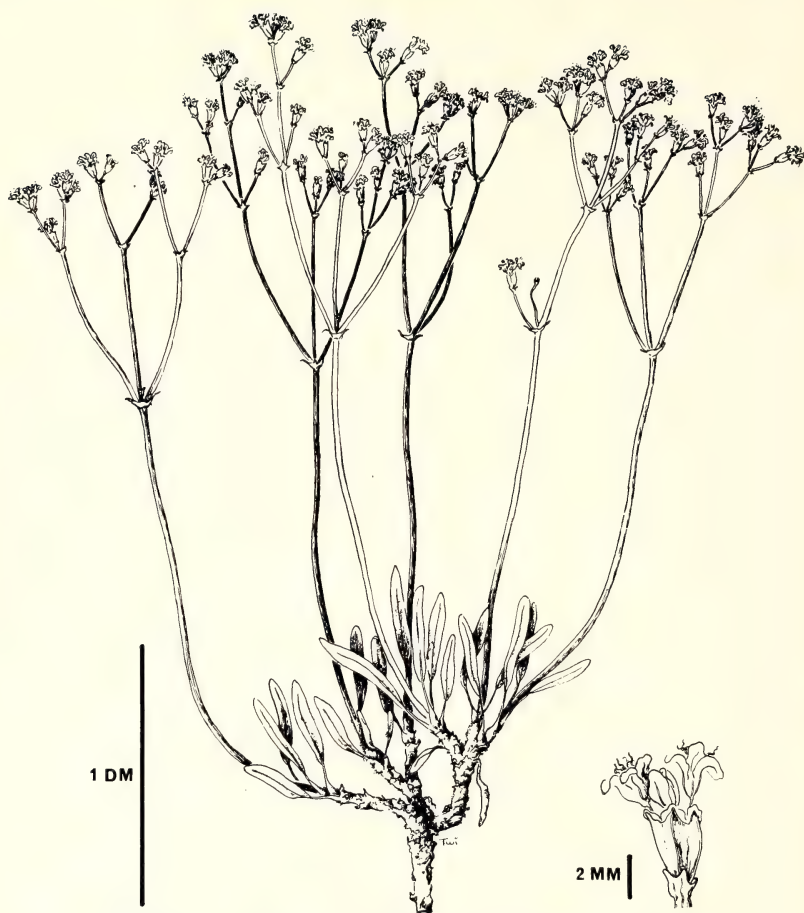


FIG. 2. *Eriogonum humivagans*. Habit sketch showing the general aspect of the species and a single enlarged involucre with exerted flowers.

longa, filamentis basi pilosis, antheris 0.4–0.5 mm longis; achenia brunnea, 2.5–3 mm longa.

Herbaceous perennials from branched woody caudices, plants 2–3 dm high; leaves strictly basal, leaf-blades 1.5–3 cm long, 2–5(7) mm wide, oblanceolate, densely white-tomentose below, sparsely tomentose and green above, the petioles 5–10(12) mm long, tomentose, the expanding petiole-bases 1.5–2 mm wide, tomentose within and without; stems glabrous except at the base among the leaves, the stems spreading outward from the 5 acute teeth which form lobes  $\frac{1}{4}$  the length of the tubes, bracts scale-like, ternate, 2–3 mm long, tannish-green to brown and glabrous without, arachnoid-pubescent within, the acute apices widening to connate bases; inflorescences open, cymose, somewhat narrow and strict, trichotomously branched, glabrous; involucre sessile, turbinate, 3–4 mm long, 2–2.5 mm wide, glabrous without, sparsely pubescent in the center of the lobes within, angled with 5 distinct ribs running down-



ward from the 5 acute teeth which form lobes  $\frac{1}{4}$  the length of the tubes, the teeth with membranaceous margins, the bractlets linear, 3 mm long, the pedicels 2.5–4 mm long, glabrous; perianth white with reddish-brown midribs and greenish-brown bases, 3–3.5 mm long, glabrous except for minute tack-shaped glands along the midribs within, calyx-segments similar, obovate, connate less than  $\frac{1}{5}$  its length; stamens 3–5 mm long, the filaments pilose at the base, the anthers 0.4–0.5 mm long, white to red; achenes light brown, 2.5–3 mm long, the subglobose bases tapering to 3-angled, slightly roughened beaks.  $n = 20$ .

Specimens examined. Utah, San Juan Co.: On low clay hills and banks, 13.5 mi E of Monticello, Sec 7, T34s, R26E, 6,800 ft, *Holmgren & Reveal 3001* (holotype-UTC); 10 mi E of Monticello, *Goodman 5999* (UC); 13 mi E of Monticello, *Waterfall 15115* (UC, US). Fig. 2.

*Eriogonum humivagans* is a member of a difficult group of species that has suffered considerable misinterpretation in various manuals and floras, and to some degree, also in Stokes (1936). This species, as well as the following one, are closely related to *E. scoparium* Small of western Colorado. These three species all have similarly shaped leaves, but *E. humivagans* differs in its inflorescence which is more strict, and the branching pattern of the lower stems which are more spreading, and in various technical characteristics and features of the involucre and perianth parts. In many respects, the new species approaches *E. nudicaule* (Torr.) Small on northern New Mexico, but *E. nudicaule* has leaves that are considerably longer and narrower than in this group of species. Of the more technical features, *E. humivagans* may be distinguished by its larger flowers and in its more narrow involucre. The basal spreading pattern which is designated in the species name is not unique, but it is not found in the following new species.

***Eriogonum intermontanum*** Reveal, sp. nov. Herba perennis, 1.5–3 dm alta; laminae foliorum anguste lanceolatae, (2)3–5 cm longae, 2–4 mm latae, subtus albo-tomentosae, supra subglabrae vel floccosae et virides, petiolis 1–2 cm longis, tomentosis, basi expansa petioli 1–1.5 mm lati; caules glabri, 10–15 cm longi, bracteis 1–3 mm longis, extra glabris, intus arachnoido-pubescentis; inflorescentiae cymosa, 2–10 cm longae; involucrea turbinato-campanulata, 2.5–3.5(4) mm longae, 2–3(4) mm latae, sessilia, extra glabri, intus sparsi tomentosa, 5–6-lobata, bracteolis linearis, 3–4.5 mm longis, pedicellis 2.5–4 mm longis, glabris; perianthia alba, costa virides vel rubella, 2–3 mm longa, extra glabra, intus minute glandulosa, segmentis similibus, obovatis; stamina 2.5–4 mm longa, filament basi pilosis, antheris 0.4–0.5 mm longis; achaenia brunnea, 2.5–3 mm longa.

Herbaceous perennials from branched woody caudices, plants 1.5–3 dm high; leaves basal or sheathing up the stems less than 1 cm, leaf-blades (2)3–5 cm long, 2–4 mm wide, narrowly lanceolate, densely white-tomentose below, floccose to subglabrous and green above, the petioles 1–2 cm long, tomentose, the expanding petiole-bases 1–1.5 mm wide, tomentose within and without; stems slender, green and glabrous, erect,



FIG. 3. *Eriogonum intermontanum*. Habit sketch showing the erect stems and arrangement of the basal leaves with an enlargement of an involucre cluster and exserted flowers, and a single involucre in the forks of the branches subtended by a ternate bract.

10–15 cm long; bracts scale-like, ternate, 1–3 mm long, narrowly triangular to linear, glabrous without, arachnoid-pubescent within, widening from acute apices to connate bases; inflorescences open, cymose, 2–10 cm long, trichotomously branched throughout, glabrous; involucre turbinate-campanulate, 2.5–3.5(4) mm long, 2–3(4) mm wide, sessile, 2–5 involucre per cluster, rarely only one, glabrous and reddish without, sparsely pubescent along the lobes within, angled with 5 or 6 distinct ribs running down from the acute teeth which form lobes ca.  $\frac{1}{4}$  of the length of the tubes, the bractlets linear, 3–4 mm long, densely hirsutulous with long marginal cells above, becoming short and capitate below, the pedicels 2.5–4 mm long, glabrous; perianth white with greenish, reddish, or reddish-brown midribs and perianth tubes, 2–3 mm long, glabrous except for minute gland-tipped hairs along the midribs within, calyx-segments similar, obovate, connate less than  $\frac{1}{4}$  their length; stamens excluded, 2.5–4 mm long, the filaments pilose at the bases, the anthers reddish-purple, 0.4–0.5 mm long; achenes brown, 2.5–3 mm long, the subglobose bases tapering to 3-angled beaks.

Specimens examined. Utah, Grand Co.: About 1.5 mi S of Uintah Co. line at head of Middle Canyon of West Water Creek drainage in Roan Cliffs, near a cattle pen, Sec 33, T15½S, R24E, 8,400 ft, *Holmgren, Reveal, & LaFrance* (holotype-UTC), July 27, 1965, distributed from UTC as *E. tristichum* Small; Roan Cliffs, *Despain* s. n. (BRY). Fig. 3.

*Eriogonum intermontanum* is probably most closely related to *E. scoparium* Small, but keys out to *E. tristichum* in Harrington's Manual (1954). However in reviewing type material, *E. tristichum* seems to be a synonym of *E. nudicaule* (Torr.) Small, but considerable field work is necessary to prove this. Nevertheless, the leaves of the new species are shorter than either. From *E. scoparium*, the new buckwheat differs in its larger stature and size of its various parts, in its more open inflorescence, and by having its involucre clustered, and only rarely singular as is the typical situation in related taxa. Ecologically *E. intermontanum* differs from these species. Normally members of this section occur on gumbo clay hills at elevations mostly below 7000 feet. However, this species occurs on gravelly loam soils above 8000 feet elevation where none of the related species occur. It is of some interest to note that the perianth and involucre are exceedingly similar to those of *E. panguicense* (M. E. Jones) Reveal of the section *Capitata* Torr. & Gray, of Southwestern Utah. However as the two do not belong to the same section, they are not believed to be closely related.

***Eriogonum ephedroides*** Reveal, sp. nov. Herba erecta, 2–3.5 dm alta; laminae foliorum lanceolatae, 1.5–2.5 cm longae, 2–3 mm latae, basiles, subtus albo-tomentosae, supra subglabrae vel glabrae et virides, petiolis 5–10 mm longis, basi expansa petioli 3–3.5 mm lati, extra glabra, intus tomentosa; caules glabri, basi excepta, ca. 2 dm longi, bracteis 1–4(7) mm longis; inflorescentiae cymosa, 1.5–2.5 dm longae, stricta, glabrae; pedunculi erecti, inferiores 5–15 mm longi, superiores perbreves; involucre turbinata, 2–2.5 mm longa, extra glabra, intus  $\pm$  tomentosa, 5-lobata, bracteolis oblanceolatis, 2 mm longis, pedicellis 2–3 mm longis, glabris; perianthia citrea vel flava, 2–2.5 longa, extra glabra, intus minute glandulosa, segmentis similibus, lanceolatis; stamina 1.5–2 mm longa, filamentis basi pilosis, antheris 0.4–0.5 mm longis, oblongis, flavis; achaenia brunnea, 2 mm longa.

Erect herbaceous perennials from gnarled woody branching caudices, 2–3.5 dm high; leaves strictly basal, 1.5–2.5 cm long, 2–3 mm wide, lanceolate, not revolute, densely white-tomentose below, subglabrous to glabrous and green above, the petioles 5–10 mm long, expanding into membranaceous petiole-bases 3–3.5 mm wide, glabrous and tan to light brown without, tomentose within; stems glabrous and bright green, up to 2 dm long; bracts scale-like, ternate, 1–4(7) mm long, linear, the acute apices widening to connate bases; inflorescences narrowly cymose, strict, 1.5–2.5 dm long, trichotomously branched at the first node, dichotomous or trichotomous above; peduncles erect, stout, 5–15 mm long

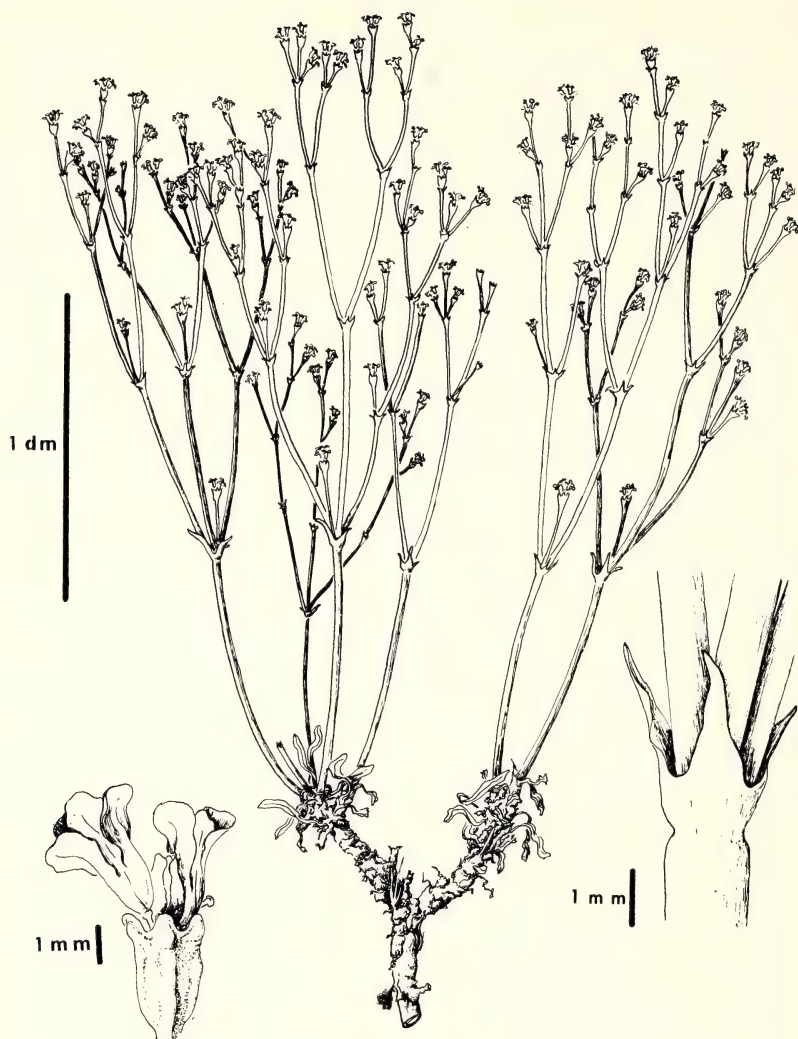


FIG. 4. *Eriogonum ephedroides*. Habit sketch showing the narrowly erect stems and arrangement of the basal leaves with an enlargement of a single involucre with exserted flowers and an enlarged section of the stem at the node showing the ternate bract.

below, becoming subsessile to sessile above; involucre turbinate, 2–2.5 mm long, glabrous without, sparsely pubescent within, the 5 acute lobes 0.5 mm long, the bractlets 2 mm long, oblanceolate, minutely gland-tipped along the margins, the pedicels 2–3 mm long, glabrous; perianth lemon-yellow to yellow, 2–2.5 mm long, glabrous except for minute glands along the midribs within, calyx-segments similar, lanceolate, con-



nate ca.  $\frac{1}{4}$  their length; stamens 1.5–2 mm long, the filaments pilose at the bases, the anthers 0.4–0.5 mm long, yellow; achenes brown, 2 mm long, the subglobose bases tapering to 3-angled beaks.

Specimens examined. Utah, Uintah Co.: About 10 mi S of Bonanza along Utah highway 45, on broken white shale slopes, S of White River, Sec 20, T10S, R25E, 5,600 ft, *Holmgren, Reveal, & LaFrance* 2265 (holotype-UTC), July 25, 1965, distributed from UTC as *E. brevicaule* Nutt. var. *leptothecum* (S. Stokes) Reveal; White River, *Ripley & Barneby* 8738 (CAS, NY); N of Dragon, *Ripley & Barneby* 13161 (CAS, NY, RSA). Colorado, Rio Blanco Co.: 17 mi NW of Rangely, *Ripley & Barneby* 8741 (NY). Fig. 4.

This new and distinctive species is a member of the *E. brevicaule* Nutt. complex, and is probably most closely related to *E. viridulum* Reveal. The narrow, strict inflorescence led the author (1966b) to consider this plant to be *E. brevicaule* var. *leptothecum*. However, during the summer of 1966 detailed herbarium studies were carried out on this species which were completed during an Internship at the United States National Herbarium. This new study allowed the author to review considerable material in the entire *E. brevicaule* complex, and this revealed the distinctiveness of *E. ephedroides*. While the new species does resemble var. *leptothecum* which is restricted to the Front Ranges of Colorado in stature, it differs in leaf size and shape, and in the arrangement appear racemose, and in the wider and nonrevolute leaves. Both species differs in its unique inflorescence which, upon a casual observation would appear racemose, and in the wider and nonrevolute leaves. Both of species grow in the same general area. However, *E. viridulum* is found north and west of the known sites of *E. ephedroides*.

The bright green and glabrous stems are not unique for the genus, yet they make *E. ephedroides* stand out against the light gray to white shale slopes upon which it grows. In the field, one notes the loosely compacted, woody, and gnarled root system. From this root, numerous branches arise, and this gives the plant the appearance of an inverted haystack, with the rounded part at the root, and the flat-topped part above.

The name for this new plant is selected for the striking resemblance it has with an associated species, *Ephedra torreyana* S. Wats., in its bright green stems and lemon-yellow flowers.

ERIOGONUM THOMPSONAE S. Wats., Amer. Naturalist 7:302. 1873. Herbaceous perennials from branched woody caudices, plants 2–4 dm high; leaves basal or sheathing up the stems less than 2 cm, leaf-blades (2)3–4.5(5) cm long, 8–15 mm wide, oblong to oblanceolate or elliptic, densely white-tomentose below, glabrous and green above, the petioles 3–7 cm long, tomentose, the expanding petiole-bases 3–4 mm wide, densely tomentose on both surfaces; stems green and glabrous, erect, 12–25 cm long; bracts scale-like, ternate, 2–5(7) mm long, linear, glabrous, the acute apices widening to connate bases; inflorescences open cymes, trichotomously divided at the first node, dichotomous or trichoto-



mous above; involucre sessile, turbinate, 2–3(3.5) mm long, 1–1.5(2) mm wide, green and glabrous without, white-glaucous and glabrous within, the 5 acute lobes ca. 0.5 mm long, the bractlets narrowly-oblongate, 2–3 mm long, the pedicels 3–4 mm long, glabrous; perianth yellow or white, 3–3.5 mm long, glabrous except for microscopic protuberences along the midribs within, calyx-segments similar, oblong to obovate, connate only at the base; stamens 2–4 mm long, the filaments sparsely pilose at the bases, the anthers 0.3–0.5 mm long, yellow; achenes light brown to brown, 2.5–3 mm long, the subglobose bases tapering to roughened 3-angled beaks. Fig. 5.

*ERIOGONUM THOMPSONAE* var. *THOMPSONAE*. Calyx yellow; involucre (2.5)3–3.5 mm long, 1–1.5 mm wide.  $n = 20$ .

Specimens examined. Utah, Kane Co.: Sandstone cliffs near Kanab, *A. P. Thompson* s. n., 1872 (BRY-photographs and illustrations, GH-holotype, NY!, UC-fragment!, US-fragment!); Kanab, *Holmgren & Reveal* 2993 (BRY, NY, UTC). Arizona, Mohave Co.: 9 mi W of Pipe Springs, *Parker et al.* 6242 (CAS, US).

*ERIOGONUM THOMPSONAE* var. *albiflorum* Reveal, var. nov. A var. *thompsonae* perianthiis albis differt. Calyx white; involucre 2–3 mm long, 1.5–2 mm wide.  $n = 20$ .

Specimens examined. Utah, Washington Co.: 3 mi W of Virgin, on basaltic gravelly soils associated with *Larrea*, Sec 19, T41S, R12W, 3,700 ft, *Holmgren & Reveal* 2991 (holotype-UTC), Aug. 11, 1966; 3.7 mi W of Virgin, *Dress* 4764 (GH).

The new collection of *E. thompsonae* var. *thompsonae* from Utah is the first one to have been made since the type was collected by Mrs. Thompson near Kanab in 1872. Except for the Arizona collection cited above, the species has been virtually unknown. With the discovery of what appeared to be a new variety of *E. thompsonae*, it became important that an attempt be made to relocate this seemingly rare plant. Following the label data, a brief search was made along the sandstone cliffs north of Kanab, but the species was not seen. However, along the hills northeast of Kanab, and near the local baseball diamond, *E. thompsonae* was found growing abundantly along the lower slopes of the red sandstone cliffs.

The minor distinction of flower color and involucre size which separates the two varieties are augmented by the distinct edaphic differences seen in the two type localities. At Kanab, var. *thompsonae* is restricted to the red sandstone, while the var. *albiflorum* is found on basaltic gravels near Virgin. In the field, the growth habit of var. *albiflorum* is more spreading than in var. *thompsonae* which tends to be more erect and not as dense in the crown.

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FIG. 5. *Eriogonum thompsonae*. Habit sketch showing the general aspect of the species.

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#### NOTES AND NEWS

THE SOUTHERN LIMIT OF *TAXUS BREVIFOLIA* IN THE SIERRA NEVADA, CALIFORNIA  
 —Current manuals describe the southern limit of distribution of *Taxus brevifolia* Nutt. in the Sierra Nevada as Tulare County. A recent search of herbaria (A, CAS, DS, GH, Herbarium of Fresno State College, JEPS, POM, RSA, UC, US, USFS, and USNA) and field studies have failed to turn up any locality south of Calaveras Co., 150 miles to the north. A collection from Yosemite Valley in 1874 (Lemmon, DS, US) appears to represent an erroneous record in view of the lack of more recent collections from Yosemite and the careless manner in which the Lemmon Herbarium was handled, and thus this record has been disregarded.

Earliest mention of Tulare Co. as the southern limit of *T. brevifolia* in the Sierra Nevada goes back to C. S. Sargent's *Silva of North America* (10:65. 1896). Twelve years earlier in his *Report on the Forests of North America*. (Department of the Interior. Washington, D. C. 1884), Sargent had described the distribution as "Sierra Nevada to about 37°N," or central Fresno Co. In view of the evidence presently available it seems plausible that these early reports of *Taxus* from southern Sierran counties are attributable to errors in collection records or field misidentifications, possibly of *Torreya californica* Torr. The southernmost occurrence of *T. brevifolia* in the Sierra Nevada is now considered to be Calaveras Co. (North Grove, Calaveras Big Trees State Park, 4800 ft., Rundel 1887, DUKE).—P. W. RUNDEL, Department of Botany, Duke University, Durham, North Carolina.



# THE EFFECT OF MISSING DATA AND OF TWO SOURCES OF CHARACTER VALUES ON A PHENETIC STUDY OF THE WILLOWS OF CALIFORNIA

THEODORE J. CROVELLO

Numerical taxonomy is still in a phase of expansion and evaluation. New methods continue to appear and more and more taxonomists are using it to estimate phenetic relationships among plant taxa. Gilmartin (1967) provided an extensive bibliography of recent numerical taxonomic applications in botany. Sokal and Sneath (1963) review earlier works.

Concurrent with the development of numerical taxonomy, the use of computers in biological collections and floras has increased. Crovello (1967) lists the uses of electronic data processing in biological collections. Some uses do not involve measurements of characters on specimens, but for other purposes the measurements given in floras would be very helpful. Before information in floras can be employed, the reliability of the measurements provided in a floristic treatment and the problem of missing data must be investigated. By reliability of measurements I mean how accurate they are in estimating the parametric values (e.g., the mean and standard deviation) of a certain character in a given taxon. The problem of missing data arises because many floras are written without the prior preparation of a complete taxon by character table. Many floristic taxonomists include values of a character only in those taxa where the characters are diagnostic of it. This is brought about partly because preserved specimens rarely have all stages of the life cycle present.

The purpose of the present study is twofold: 1, to test the effect of missing data on a phenetic study of a group of plants, and 2, to ascertain the reliability of two sources of information about characters in taxospecies, one arising from a floristic treatment (Munz, 1959) and the other from a study of monographic proportions (Crovello, 1966). The latter is assumed to involve more measurements per character per taxospecies than the former. The results should be of value in estimating the reliability of information from floristic studies for estimation of phenetic relationships. This is especially timely in view of the proposed Flora North America Project. A natural byproduct will be further comprehension of the pattern of variation *among* the willows of California. By this I mean the phenetic relationships among (not *within*) the taxospecies in the context of the characters used. For example, Fig. 1 indicates relationships among the willows based on 43 characters. This figure is a reflection of the pattern of variation among the taxospecies based on these 43 characters.

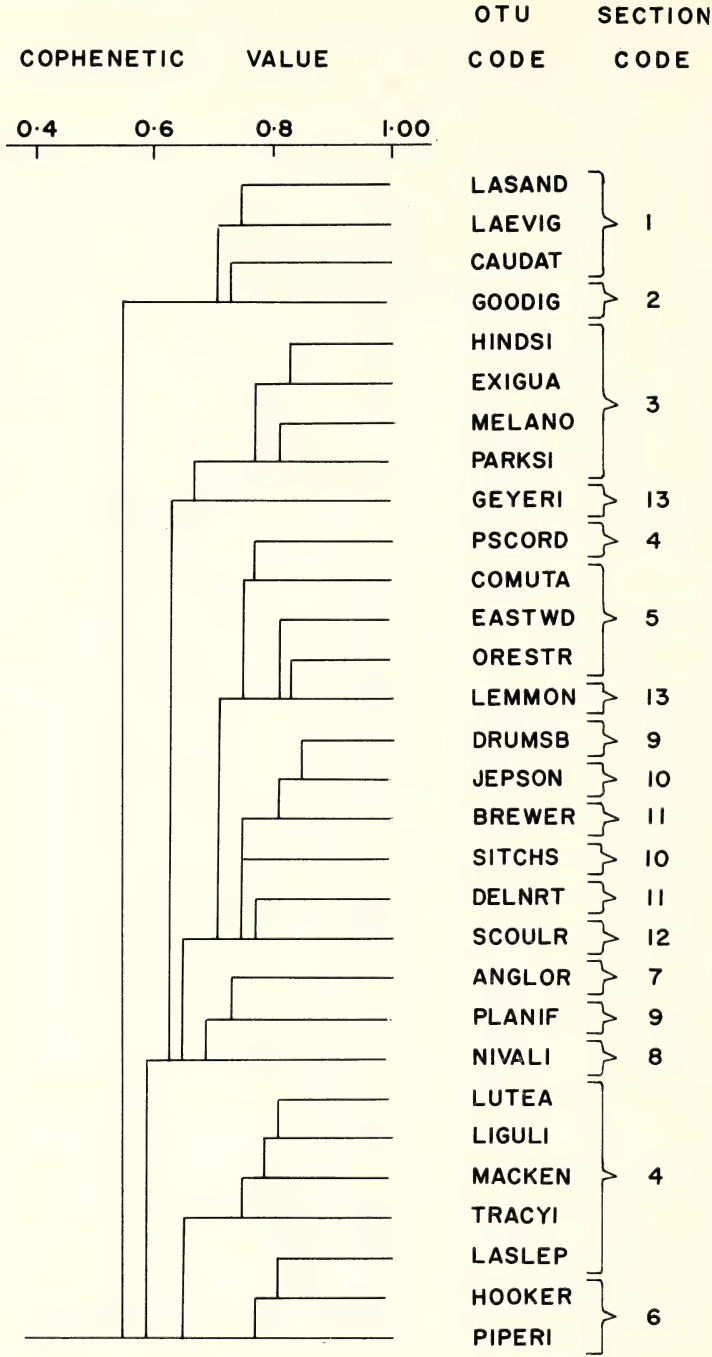


FIG. 1. Phenogram of analysis using data from Crovello (1966) for 43 characters.

## MATERIALS AND METHODS

In his floristic treatment of *Salix*, Munz (1959) used 57 morphological characters, but eight were invariant (did not distinguish any willow species) and were omitted. Of the remaining 49 characters, Crovello (1966) could not obtain information on six of them, so both studies had only 43 characters in common.

Six analyses were made. These differed only in the input data that were used in each. They are the following: 1, data from Crovello (1966) on the 43 available characters of the 57 characters used by Munz (1959); 2, data from Crovello (1966) as the previous analysis, but with the same pattern of missing information as found in Munz (1959); 3, data from Munz (1959) on 43 characters that Crovello (1966) also scored; 4, data from Munz (1959) on 49 of the 57 characters used by him; 5, data from Crovello (1966) on 131 characters; 6, data from Crovello (1966) on 202 characters. Analyses 5 and 6 were included to serve as standards with which to compare the results of the first four analyses. Two standards are considered more desirable, since no one result that uses a large number of characters can be taken as depicting the true, overall, phenetic relationships better than another analysis using many characters. With two "standards" before him, the reader has some idea of the variability of results even when information is available on over 100 characters. Table 1 lists the characters employed in the first four analyses. Crovello (1966) gives the characters used in the last two analyses. In it he treated floral characters common to both sexes, e.g., ament length, as one character, but in the present study these are treated as two characters.

For analyses 3 and 4, the information contained in the treatment of the genus by Munz (1959) was used exclusively. This includes the information located both in the keys and in the description of each species. The information under each variety was incorporated into the description of its species. The other four analyses used information gathered by Crovello (1966). He used herbarium specimens to reinforce his personal collections. From 7 to 15 plants were chosen for each of the 31 taxospecies recognized by Munz (1959) as native to California. Most plants were represented by several herbarium sheets. Crovello (1966) provides a list of specimens used. This list and copies of the taxospecies by character tables, or Basic Data Matrices (BDM's) are on file on punched cards in The Herbarium, University of Notre Dame.

Crovello (1966) concluded that *Salix coulteri* is a synonym of *Salix sitchensis*. As a result, the number of taxospecies analyzed in the present study is 30, one less than the number recognized by Munz. Table 2 lists the 30 taxospecies and their codes. They are grouped into sections according to the ideas of Schneider (1921).

There exists no one method of numerical taxonomy. The present study used only one because we are interested in the effect of different sources of data and not in the effect of different taximetric methods. Sokal and Sneath (1963) discuss a number of different methods.

TABLE 1. CHARACTERS USED IN THE PRESENT STUDY.  
THE FIRST 43 WERE USED BY CROVELLO.

1. Plant habit	30. Stigma lobe length
2. Plant height	31. Style length
3. Last year's twig color	32. Capsule length
4. This year's twig color	33. Capsule pedicel length
5. Stipules present or absent	34. Stamen number
6. Stipule length	35. Stamen filament divided
7. Stipule shape	36. Stamen filament pubescent
8. Stipule margin	37. Presence or absence of pubescence on last year's trig
9. Petiole length	38. Presence or absence of pubescence on this year's twig
10. Petiole glandular	39. Presence or absence of pubescence on abaxial leaf surface
11. Blade length	40. Presence or absence of pubescence on adaxial leaf surface
12. Blade shape	41. Presence or absence of pubescence on adaxial side of floral scale
13. Blade margin entire	42. Presence or absence of pubescence on adaxial side of floral scale
14. Blade margin glandular	43. Presence or absence of pubescence on capsule surface
15. Blade margin revolute	44. Bark texture
16. Blade base shape	45. Bark color
17. Blade apex shape	46. Blade color
18. Blade veins prominent below	47. Time of flowering compared to time of leaf break
19. Blade abaxial side glaucous	48. Ovary shape
20. Blade adaxial side lustre	49. Flowering period
21. Blade width	
22. Female ament length	
23. Male ament length	
24. Female peduncle length	
25. Female peduncle leaf number	
26. Female ament dense or lax	
27. Female floral scale length	
28. Female floral scale shape	
29. Female floral scale color	

The procedure used here was the same for each of the six analyses. For each analysis the raw data appears in the form of a taxospecies by character table, or Basic Data Matrix (BDM). Each character was transformed by condensation to remove the effect of weighting due to measurement of different characters in different units. For example, leaf length was measured in millimeters and leaf base shape was measured in angles. To give each character equal weight, each value of a certain character in the tables was condensed, i.e., the value of a character in a certain taxospecies was replaced by a value  $X_{ej}$ ,

$$X_{ej} = \frac{X_j - X_{\min}}{X_{\max} - X_{\min}}$$

where  $X_{ej}$  is the condensed value of character  $X$  in taxospecies  $j$ ,  $X_j$  is the original value of character  $X$  in taxospecies  $j$  and  $X_{\min}$  and  $X_{\max}$  are the minimum and maximum observed values of character  $X$  in the BDM.

Next, I calculated the similarity between each pair of Operational Taxonomic Units (OTU's), here the taxospecies. I used a modification of the distance coefficient introduced by Sokal (1961). Call this modifi-







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To JOHN THOMAS HOWELL, indefatigable collector and student of the plants of California and the Galápagos Islands, and long time member of the California Botanical Society, this volume of Madroño is dedicated.

Tom Howell was born in Merced where he lived until he graduated from high school. It was as a student at the University of California in Berkeley, where he came under the influence of Professor W. L. Jepson, that he developed his interest in botany. Following his university graduation and subsequent completion of a master's degree, he went to southern California, where he spent the first two years of his professional life. In 1929 at the invitation of Miss Alice Eastwood he came to the California Academy of Sciences in San Francisco where he has remained.

As a collector of botanical specimens, Tom Howell has few equals, and his collection numbers have surpassed 40,000. Moreover, his collections have never lain idle to collect dust but he has determined them and incorporated them in the Herbarium of the Academy. Although most of his collecting has been done in California and the Galápagos Islands he has made important collections in several western states. In addition to his own collections which have added so extensively to the Academy's herbarium he has encouraged many others, both amateur and professional, to make collections which also have come to the Academy.

His numerous botanical papers have contributed greatly to our knowledge of the plants of the areas where he has collected and particularly his floras of several regions in northern and central California have contributed to a greater botanical understanding of local areas.

Leaflets of Western Botany, which he and Miss Eastwood began in 1932 and which he edited and published until the end of 1966, provided a vehicle for significant contributions to the botany of the western United States.

His many years of field work, his keen observations, his great enthusiasm and unlimited energy, have brought to him an unsurpassed knowledge of California's native and weedy plants. And he is always a source of botanical information, willingly, thoughtfully and kindly given, to all who seek him out.



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JOHN H. THOMAS, Editor

November 15, 1968



TABLE 2. THE 30 TAXOSPECIES OF SALIX IN CALIFORNIA RECOGNIZED BY CROVELLO (1966). ARRANGEMENT BY SECTIONS FOLLOWS SCHNEIDER (1921)<sup>1</sup>.

Section Code	Taxospecies Symbol	Taxospecies
1. <i>Pentrandrae</i> Dumort.	LASAND	<i>S. lasiandra</i> Benth.
	CAUDAT	<i>S. caudata</i> (Nutt.) Hell.
	LAEVIG	<i>S. laevigata</i> Bebb.
2. <i>Nigrae</i> Loudon	GOODIG	<i>S. gooddingii</i> Ball
3. <i>Longifoliae</i> Anderss.	HINDSI	<i>S. hindsiana</i> Benth.
	EXIGUA	<i>S. exigua</i> Nutt.
	MELANO	<i>S. melanopsis</i> Nutt.
4. <i>Cordatae</i> Barr.	PARKSI	<i>S. parksiana</i> Ball
	LUTEA	<i>S. lutea</i> Nutt.
	LIGULI	<i>S. ligulifolia</i> (Ball) Ball
	MACKEN	<i>S. mackenziana</i> (Hook.) Barr.
	PSCORD	<i>S. pseudocordata</i> Anderss.
	LASLEP	<i>S. lasiolepis</i> Benth.
	TRACYI	<i>S. tracyi</i> Ball
5. <i>Andenophyllae</i> Schneid.	COMUTA	<i>S. commutata</i> Bebb
	EASTWD	<i>S. eastwoodiae</i> Ckll.
	ORESTR	<i>S. orestera</i> Schneid.
6. <i>Chrysanthae</i> Koch	PIPERI	<i>S. piperi</i> Bebb
	HOOKEP	<i>S. hookeriana</i> Barr.
7. <i>Ovalifoliae</i> Rydb.	ANGLOP	<i>S. anglorum</i> Cham. var. <i>antiplasta</i> Schneid.
8. <i>Reticulatae</i> Fries	NIVALI	<i>S. nivalis</i> Hook.
9. <i>Phylicifoliae</i> Dumort.	PLANIF	<i>S. planifolia</i> Pursh var. <i>monica</i> (Bebb) Schneid.
	DRUMSB	<i>S. drummondiana</i> Barr. var. <i>subcoerulea</i> (Piper) Ball
10. <i>Sitchenses</i> Bebb	SITCHS	<i>S. sitchensis</i> Sans.
	JEPSON	<i>S. jepsonii</i> Schneid.
11. <i>Brewerianae</i> Schneid.	BREWER	<i>S. breweri</i> Bebb
	DELNRT	<i>S. delnortensis</i> Schneid.
12. <i>Discolores</i> Barr.	SCOULP	<i>S. scouleriana</i> Barr.
13. <i>Fulvae</i> Barr.	LEMMON	<i>S. lemmonii</i> Bebb
	GEYERI	<i>S. geyeriana</i> Anders.

<sup>1</sup> The only exception to Schneider's assignments is *S. jepsonii*. He placed it in section *Phylicifoliae*.

cation the similarity coefficient,  $s_{jk}$ . Then,

$$s_{jk} = 1 - \left[ \frac{\sum_{i=1}^{n_{jk}} (X_{ij} - X_{ik})^2}{n_{jk}} \right]^{1/2}$$

where  $X_{ij}$  and  $X_{ik}$  are the values of character  $i$  in OTU's  $j$  and  $k$ , respectively, and  $n_{jk}$  is the total number of characters used in the particular comparison. If there were no missing data, i.e., if the OTU by OTU relevance (Sokal and Sneath, 1963) were always 1.0, then  $n_{jk}$  would be the same for all combinations of pairs of OTU's.

TABLE 3. SUMMARY STATISTICS OF THE SIX ANALYSES.

Analysis number and description	Similarity coefficient		OTU by OTU relevance		Cophenetic correlation coefficient
	$\bar{Y}$	s	$\bar{Y}$	s	
1. Crovello 43	.593	.086	.972	.037	.746
2. Crovello 43 with Munz's missing data pattern	.578	.098	.482	.082	.678
3. Munz 43	.590	.085	.495	.079	.741
4. Munz 49	.587	.082	.483	.075	.719
5. Crovello 131	.617	.077	.908	.032	.858
6. Crovello 202	.615	.072	.829	.080	.871

Each set of similarity coefficients from one BDM forms a 30 by 30 OTU by OTU table, or Basic Similarity Matrix (BSM). Each cell in it indicates how similar two taxospecies are in the context of the characters used and based on the source of the data for the BDM being analyzed. The BSM was then used to group OTU's by the unweighted pair-group method (Sokal and Sneath, 1963). This results in a phenogram, a hierarchical presentation of phenetic relationships among the OTU's, *in the context of the characters analyzed*.

#### RESULTS

Figures 1 to 4 and Tables 3 and 4 present the results of the four analyses. Figures 5 and 6 are standards with which to compare the phenograms of the analyses using Munz's characters. The last two represent the maximum information on California willows available to the author at the present time. Figure 5 is based on the morphological characters studied by Crovello (1966) but without the six (or seven) unit pubescence characters scored for each organ. Figure 6 includes the 62 unit pubescence characters. *Two* standards were used: 1, to increase comprehension of the results of the present paper; and 2, to emphasize that in numerical taxonomy any one result is not the ultimate truth. For ease of presentation of results, we shall compare Figs. 1 through 6 with the latest nonnumerical monograph, which I summarize in Table 2.

Figure 1 gives the analysis of 43 characters using full data from Crovello (1966) which produced seven clusters. Beginning at the top, the first cluster contains four taxospecies that are the only representatives in California of the subgenus *Pleiandrae*. The next four OTP's are the representatives of section *Longifoliae* appearing in California. GEYERI then joins this cluster. The next cluster of five taxospecies includes members of sections *Cordatae*, *Adenophyllae* and *Fulvae*, while the subsequent cluster includes members of sections *Phylicifoliae*, *Sitchenses*, *Brewerianae* and *Discolores* in a mixed pattern. This is followed by a cluster consisting of three high-altitude willows, ANGLOR, PLANIF and NIVALI. The next to last cluster includes four members of section *Cordatae*, while the last cluster contains LASLEP, a polymorphic member of sec-

TABLE 4. CORRELATION BETWEEN ALL PAIRS OF THE SIX SIMILARITY MATRICES (LOWER LEFT), AND CORRELATION BETWEEN ALL PAIRS OF THE SIX PHENOGRAMS (UPPER RIGHT). IN ALL CASES  $n = 435$ .

Analysis number and description	Analysis number					
	1	2	3	4	5	6
1. Crovello 43	1.000	.852	.606	.643	.715	.677
2. Crovello 43 with Munz's missing data pattern	.887	1.000	.455	.437	.460	.455
3. Munz 43	.583	.450	1.000	.947	.658	.573
4. Munz 49	.604	.460	.974	1.000	.739	.653
5. Crovello 131	.835	.669	.655	.670	1.000	.889
6. Crovello 202	.733	.585	.595	.614	.889	1.000

tion *Cordatae*, and the two taxospecies of section *Chrysanthae* that appear in California.

Turning to Fig. 2, which is based on Crovello's data but uses the pattern of missing data present in the Munz data, seven clusters also are seen here. The first is similar to that of Fig. 1. The next two clusters of three and four taxospecies resemble two from Fig. 1, but TRACYI is out of place. The next cluster includes section *Longifoliae*, but here GEYERI has split the four members of that section. The next cluster contains six taxospecies. Except for ANGLOR, it is similar to a cluster in Fig. 1. The final two clusters also have their counterparts in Fig. 1, with the exception of ANGLOR mentioned above.

Figure 3 is based on Munz's data on the 43 characters that are comparable to Crovello's. The first cluster of four taxospecies is the same as in previous figures. But then HINDSI appears as deviant from all other OTU's. The other three members of section *Longifoliae* are far removed from it. The next two clusters, the first with six taxospecies, bring together quite different OTU's as suggested by conventional taxonomy and by Figs. 1 and 2. ANGLOR is a dwarf alpine form, whereas SCOLUR is a polymorphic shrub or small tree more common at lower altitudes. By inspection of the rest of Fig. 3 the reader can ascertain the similarities and differences of it when compared to the previous figures.

Figure 4 is based on the 49 characters used by Munz. Seven more or less distinct clusters emerge. The four OTU's of section *Longifoliae* are closer together now than in Fig. 3, but as in Fig. 2, GEYERI splits them. Here EASTWD also is among this cluster. Note at the bottom of Fig. 4 that ANGLOR is still grouped with SCOLUR.

Figure 5 consists of eight clusters, the first three of which agree exactly with Fig. 1. The remainder of Figs. 1 to 4 is in less agreement with Fig. 5 and Fig. 6. Note, however, that Figs. 5 and 6 are not identical.

Table 3 gives summary statistics for the six analyses. Columns 1 and 2 list the mean and standard deviation of each of the Basic Similarity

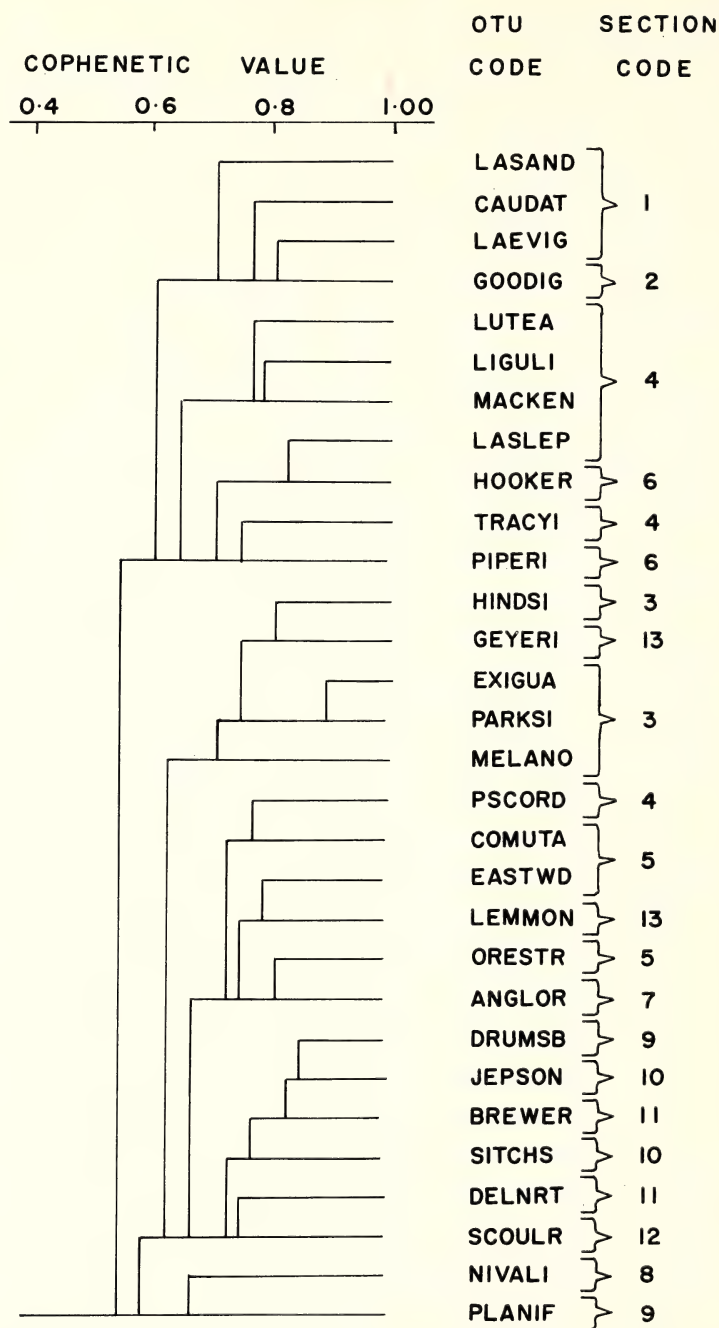


FIG. 2. Phenogram of analysis using data from Crovello (1966) for 43 characters with Munz's missing data pattern.



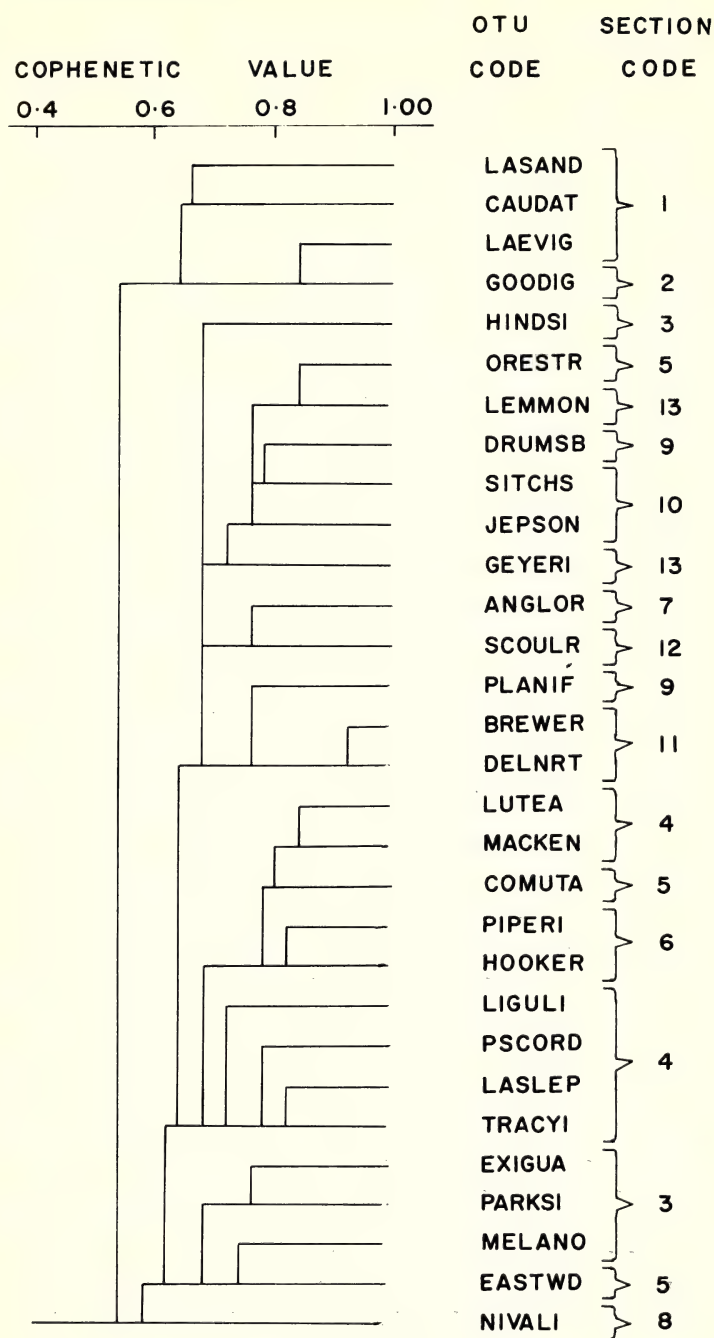


FIG. 3. Phenogram of analysis using data from Munz (1959) for 43 characters.

Matrices (BSM's). The closeness of the values is expected when each analysis is based on a high OTU by OTU relevance. But as seen from the next two columns the relevance values fluctuate considerably.

The last column of the table gives the cophenetic correlation coefficient for the six phenograms. It is the correlation coefficient obtained from a comparison of the BSM with the cophenetic values of the phenogram resulting from it (Sokal and Sneath, 1963). Since it compares a phenogram with the BSM from which it is derived, it provides an accurate estimate of how well the phenogram reflects the relationships given in the BSM. In unpublished studies the author has noted that, in general, as the number of characters increase, the value of the cophenetic correlation coefficient increases.

The lower left half of Table 4 contains the Pearson product moment correlation coefficients computed between all pairs of the similarity matrices used in the study. All of the BSM's are rather highly positively correlated, but note the extremely high values among close pairs, such as between sets 1 and 2 and sets 3 and 4. Examination of a family of such statistics in a group under study allows one to understand values characteristic of similar analyses and those characteristic of more unrelated analyses. These correlation coefficients are not to be confused with the cophenetic correlation coefficient, the values of which are found in Table 3.

Comparison of two phenograms can be made more efficient and objective by computing the coefficient of correlation between the cophenetic values obtained from the two analyses. This was done in the present study and results appear in the upper right half of Table 4. We can tell at a glance how similar are the relationships among OTU's in any two phenograms.

#### DISCUSSION

The first purpose of this study was to test the effect of missing data on a phenetic study of a group of plants. This test is achieved by comparing the results of analyses 1 and 2, in which the data are obtained from the same source, but the latter analysis purposely does not use all of it that is available. From Tables 3 and 4, the surprising fact is that even though the average OTU by OTU relevance is halved from 0.972 to 0.482, still the correlation between the two BSM's is 0.887. This strongly suggests that a phenetic analysis can tolerate a good amount of missing data and still give reasonably consistent results.

The second purpose of the study was to ascertain the reliability of two sources of estimation of values of characters in taxospecies. This is accomplished by comparing results of the second and third analyses. From Table 3, the average similarity values are approximately equal, as are the average relevance values. The average relevance value of analysis 3 is slightly higher than that of analysis 2 because there was a certain amount of missing data in Crovello's original BDM. From Table 4 the

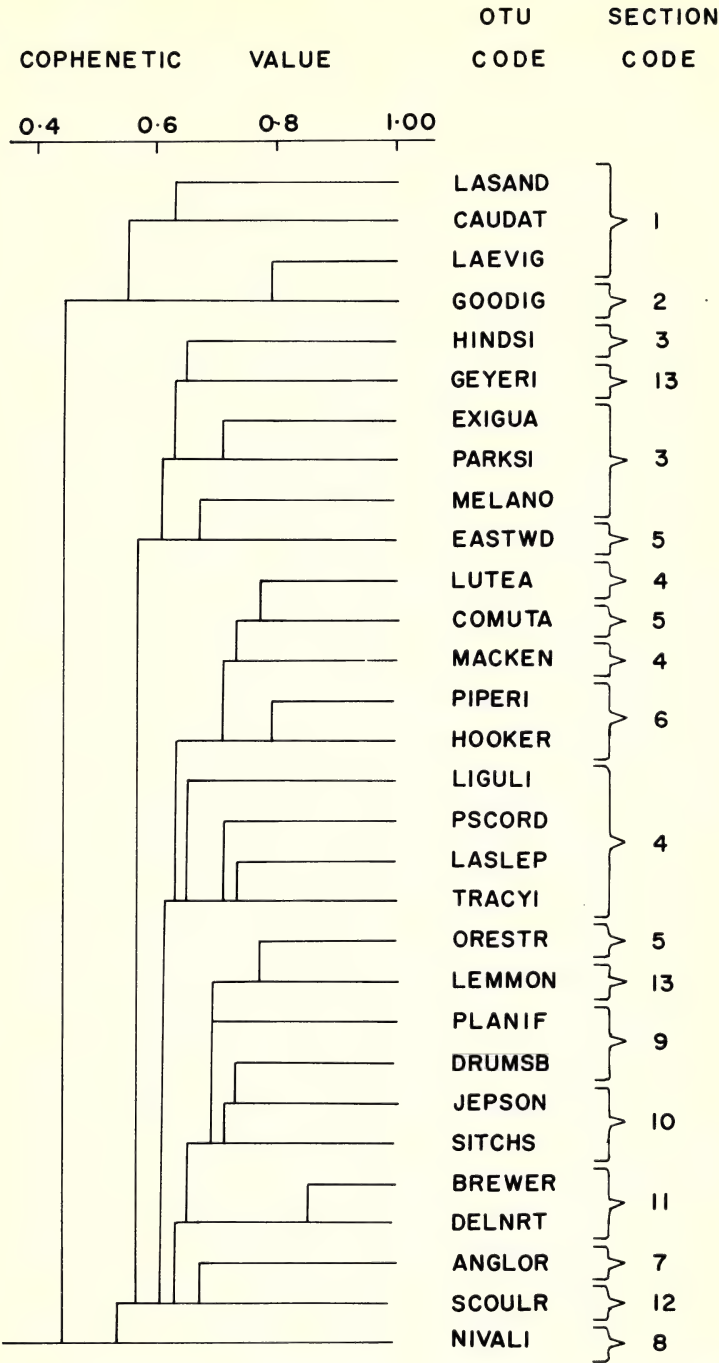


FIG. 4. Phenogram of analysis using data from Munz (1959) for 49 characters.

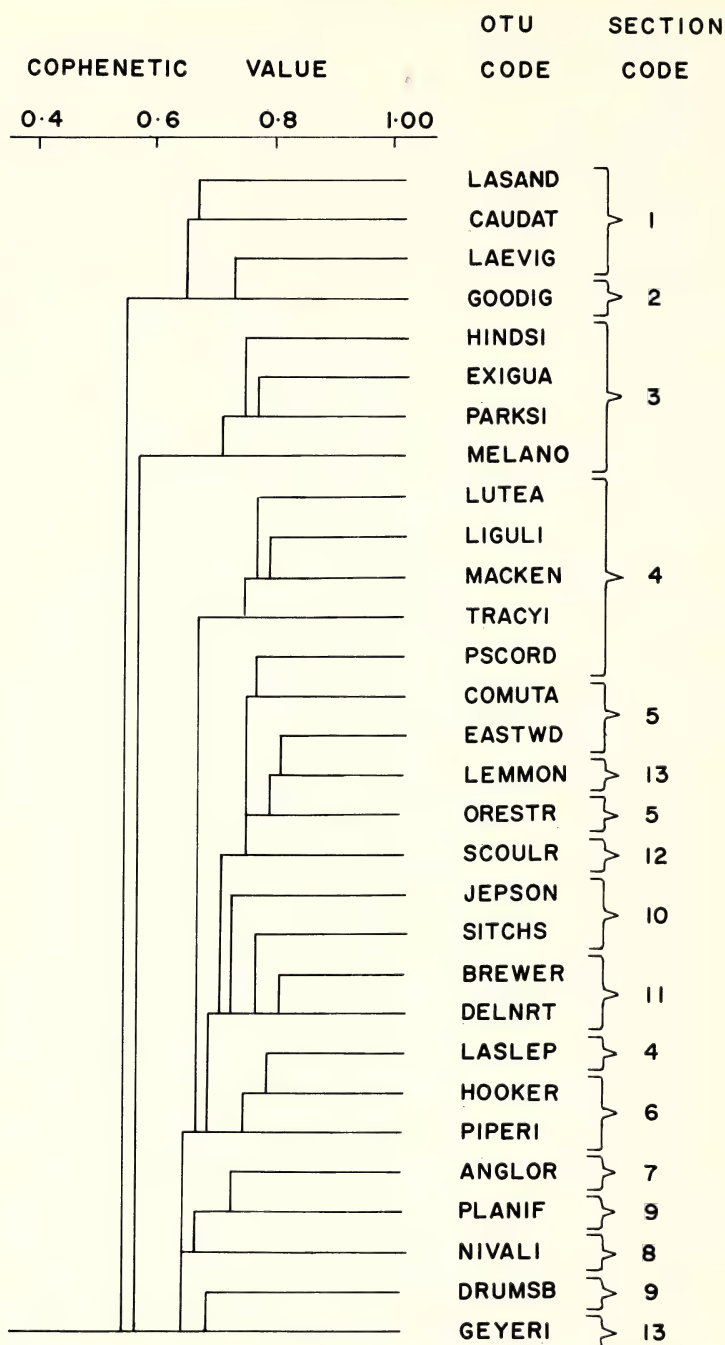


FIG. 5. Phenogram of analysis using data from Crovello (1966) for 131 characters.



correlations between BSM's 2 and 3 and between phenograms 2 and 3 are extremely low in comparison to such pairs of analyses as 1 and 2, 3 and 4, and 5 and 6.

Now compare in Table 4 the results of analysis 2 with the standards (5 and 6) and of analysis 3 with the standards. Even though 2 and 3 show low similarity with each other, both show medium level similarity to the two standards. Furthermore, the correlations of the phenogram of analysis 3 with the two standards is higher than those of analysis 2 with the two standards. The reason for this is not clear at present, but it does indicate that data from floristic studies may be much more reliable than previously thought. However, for maximum reliability the missing data will have to be supplied from outside sources *before* such information is processed.

In summary, when we consider all the analyses, what emerges is not a qualitative yes-no agreement or disagreement, but rather a continuum. Munz's information does not agree well with Crovello's information on the same characters. Crovello's analysis of 43 characters using full data agrees more with the standards than do those of Munz. (This is to be expected, since the BDM of Crovello's 43 characters is a subset of that of the standards). Low OTU by OTU relevance had to cause the drop in correlation between analyses 2 and 5 and 2 and 6, as compared to analyses 1 and 5 and 1 and 6.

We may conclude that missing data does make a difference and that distortion of phenetic relationships may result when data from floras are used directly without supplementary information, both to supply the missing data on characters used and to supply information on characters not used at all. But although distortion is present, a rough idea of relationships can be obtained, as shown by the phenogram.

#### SUMMARY

The effect of missing data and of two methods of estimation of character values on a phenetic study of the willows of California was investigated. This was accomplished by comparison of the data from the floristic study of Munz (1959) with the study of Crovello (1966). Techniques of numerical taxonomy compared six analyses of data obtained from the two studies. Since Crovello had almost no missing data for 43 of the characters used by Munz while Munz had a considerable amount of missing data, the effect of missing data could be determined. Missing data was found to distort the relationships among willows. Next, a comparison of Munz's data for 43 characters with data from Crovello but with Munz's missing data pattern served to estimate the effect of the reliability of the data from these two sources. As expected, the agreement between the two was low. But both still agreed moderately well with the standard analyses. The overall conclusion is that direct data from floras can be valuable in a numerical taxonomic study. But its value is enhanced when missing data is supplied and when the number

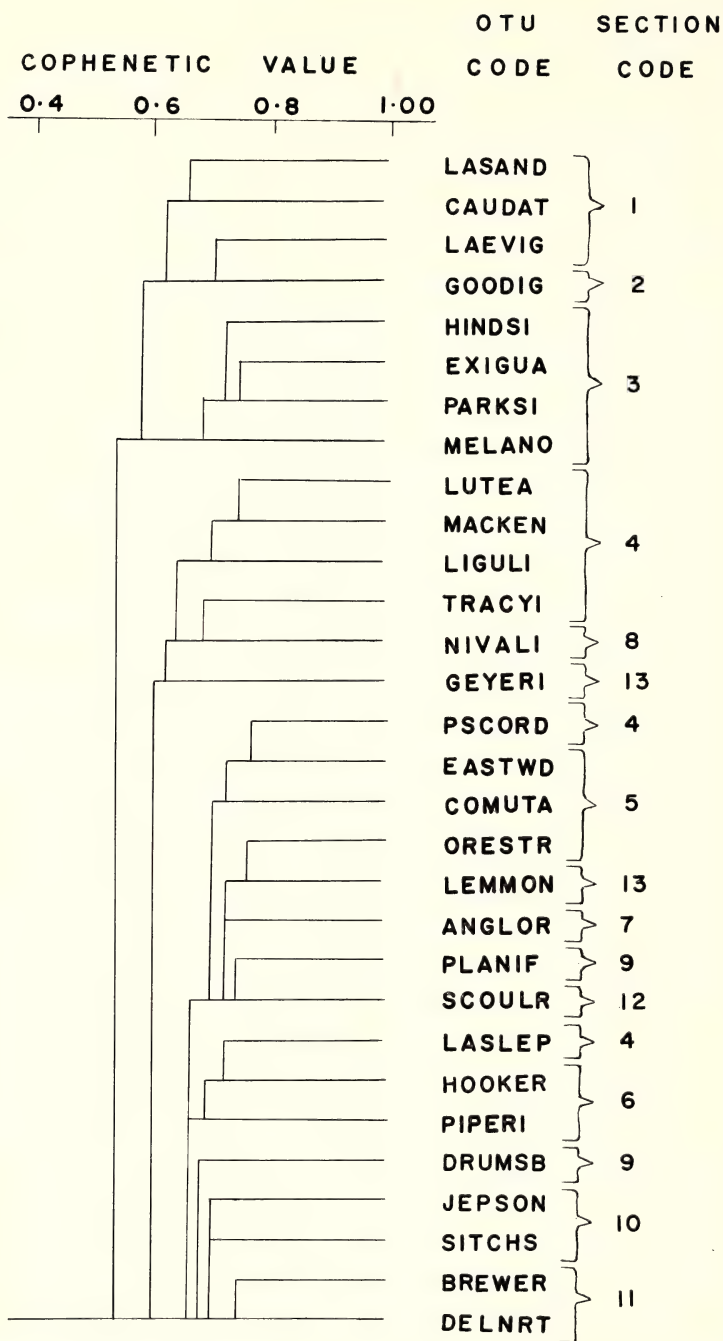


FIG. 6. Phenogram of analysis using data from Crovello (1966) for 202 characters.

of characters is increased. The present study also suggests that much information on phenetic relationships present in floras is not used. Such information could be revealed by the regular use of taximetric methods. Finally, use of the techniques described above now permits the taxonomist to compare, in a reliable and consistent manner, relationships suggested in a floristic study with those presented in a monograph.

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